TRANSACTIONS

OF THE

ROYAL SOCIETY OF SOUTH AFRICA

VOLUME XX.

1932.

WITH FOURTEEN PLATES

CAPE TOWN:
PUBLISHED BY THE SOCIETY.

1932.

C.85
C33
v.20

OHIO STATE
UNIVERSITY

Printed in Great Britain by
NEILL & CO., LTD., EDINBURGH.

CONTENTS

PAGE

THE LAST CHAPTER OF THE *De Fabrica* OF VESALIUS, ENTITLED SOME OBSERVATIONS ON THE DISSECTION OF LIVING ANIMALS. Translated from the Latin by BENJAMIN FARRINGTON . . . 1

SOUTH AFRICAN BRYOPHYTA. Further Notes. By Dr. T. R. SIM, Maritzburg 15

NOTE ON A SPECIAL HERMITIAN DETERMINANT. By Sir THOMAS MUIR, F.R.S. 33

ON THE HERPETOLOGICAL FAUNA OF THE LOBATSI-LINOKANA AREA. By J. H. POWER. (With Appendix and two Text-figures) . 39

AN ILLUSTRATED ANALYSIS OF PREHISTORIC ROCK-PAINTINGS FROM PELZER'S RUST. By C. VAN RIET LOWE. (With two Text-figures) 51

A RARE POINT FROM SHEPPARD ISLAND. By C. VAN RIET LOWE. (With one Text-figure) 57

THE ALKALOIDS OF THE BARK OF *Strychnos Henningsii* (Second Communication). By M. RINDL, Department of Chemistry, Grey University College, Bloemfontein 59

CRYSTALS FROM THE KIMBERLEY MINES. By E. D. MOUNTAIN, M.A., Professor of Geology and Mineralogy, Rhodes University College, Grahamstown. (With Plate I, and twelve Text-figures) 65

THE BUSHMEN-HOTTENTOT-STRANDLOOPER TANGLE. By T. F. DREYER, Grey University College, Bloemfontein. (With Plate II, and four Text-figures) 79

THE INFLUENCE OF FLUORIDES ON THE REDUCTION OF POTASSIUM PERMANGANATE. Part I.—REDUCTION WITH ANTIMONIOUS SALT. By W. PUGH 93

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE FRESHWATER ALGAE OF AFRICA. 9. *Freshwater Algae and Phytoplankton from the Transvaal.* By GUNNAR NYGAARD (Copenhagen). Communicated by Miss E. L. STEPHENS. (With forty-eight figures in the Text) 101

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE FRESHWATER ALGAE OF AFRICA. 10. *Phytoplankton from South African Pans and Vleis.* By FLORENCE RICH. Communicated by Miss E. L. STEPHENS. (With twenty figures in the Text) 149

THE GENUS *Anthephora*, SCHREB. By A. P. GOOSSENS, M.Sc., Botanist, National Herbarium, Pretoria. Communicated by E. P. PHILLIPS. (With four Text-figures) 189

SOUTH AFRICAN MAY-FLIES (*Ephemeroptera*). By K. H. BARNARD, D.Sc., F.L.S. (With forty-eight Text-figures) 201

495688

PAGE

CONTRIBUTIONS TO A KNOWLEDGE OF THE TRANSVAAL IRIDACEAE. PART II. By N. E. BROWN, A.L.S. (Communicated by J. BURTT DAVY, M.A., Ph.D.) 261

PERCEPTUAL TESTS OF "GENERAL INTELLIGENCE" FOR INTER-RACIAL USE. By MEYER FORTES, M.A., Ph.D. (Psychological Laboratory, University College, London). (Communicated by Professor H. A. REYBURN) 281

THE GLACIATED SURFACES OF NOOITGEDACHT, NEAR KIMBERLEY, AND THE UPPER DWYKA BOULDER SHALES OF THE EASTERN PART OF GRIQUALAND WEST (CAPE PROVINCE), 1929. By GEORGE SLATER, D.Sc., D.I.C., A.R.C.S., Imperial College of Science and Technology, London. With a Note on the Erratics by A. L. DU TOIT, D.Sc. (Communicated by S. H. HAUGHTON, D.Sc.) (With Plates III–XII, and three Text-figures) . . 301

THE STABILITY OF BROMIC ACID AND ITS USE FOR THE DETERMINATION OF BROMIDE IN BROMATES AND IN CHLORIDES. By W. PUGH, Ph.D. 327

A SEASONAL STUDY OF THE MICROFLORA AND MICROFAUNA OF FLORIDA LAKE, JOHANNESBURG, TRANSVAAL. By JOHANNA F. M. SCHUURMAN, Department of Zoology, University of the Witwatersrand. (With Plate XIII, one Text-figure, and Graphs I–VII) 333

THE PARASITISM OF *Harveya speciosa* BERNH. By ELAINE M. YOUNG. (With Plate XIV, and seven Text-figures) 387

TRANSACTIONS

OF THE

ROYAL SOCIETY OF SOUTH AFRICA.

VOL. XX

THE LAST CHAPTER OF THE *DE FABRICA* OF VESALIUS

ENTITLED

SOME OBSERVATIONS ON THE DISSECTION OF LIVING ANIMALS.

Translated from the Latin by BENJAMIN FARRINGTON.

TRANSLATOR'S NOTE.

The physiological experiments here described were instituted by Vesalius as a regular part of his anatomical demonstrations at the University of Padua and mark the beginning of modern physiology. They have a direct bearing on the series of experiments by which Harvey was enabled to demonstrate the circulation of the blood. Harvey studied at Padua from 1598 to 1602 under Fabricius of Aquapendente, who then held the chair. His predecessor in the chair was Falloppius, a favourite pupil of Vesalius himself. Of his debt to Vesalius, Harvey was well aware (*cf.* Roth, *Andreas Vesalius*, Berlin, 1892, p. 298).

The experiments of Vesalius, however, were not all new. The *De Fabrica* appeared in 1543. Two years earlier appeared that monument of Renaissance scholarship, the complete Latin Galen, published by the firm of Junta, in Venice. For this work Vesalius revised, and almost re-wrote, the translation of three treatises of Galen, "On the Dissection of the Nerves," "On the Dissection of the Veins and Arteries," and "On Anatomical Operations." Most of the experiments of Vesalius will be found described in these or other works of Galen. The importance of Vesalius's work in physiology lies not so much in his having originated experiments as, firstly, in his having revived the practice, and, secondly, in the absence of windy speculation, from which Galen is not free. The physiology of Vesalius is

the physiology of Galen *viewed with suspicion*. He has broken free from philosophy. The mental attitude of Vesalius is already that of Harvey.

My references to Galen are to the ninth edition (Venice, 1625) of the Latin version. This contains the revisions of Vesalius. I have inserted in the left margin references to the various books of the *De Fabrica* in which the subject-matter to which the experiments refer is treated of. Vesalius gives abundant references to the illustrations in the various books of the *De Fabrica*, without which it would be extremely difficult to identify the various parts of which he speaks. But unless one were to reproduce all his figures there could be no point in reproducing the references.

I owe a deep debt of gratitude to my colleague, Dr. Haines, for helping me to make these identifications and supplying me with the modern names, which are printed in brackets.

B. F.

University of Capetown,
April 1931.

The Last Chapter (Book vii, Chap. 19) of *The Mechanism of the Human Body.*

By Andreas Vesalius.

Some Observations of the Dissection of Living Animals.

What is to be learned by the Dissection of Dead, and what by that of Living Animals.

Dissection of dead bodies gives accurate instruction in the number, position, and shape of each part, and its particular substance and composition ; vivisection sometimes plainly shows the function itself, and sometimes supplies helpful arguments leading to its discovery. Wherefore it is proper that students should first come for training on dead animals, in order that when they afterwards proceed to investigate the action and use of the parts, they may be prompt in their approach to the living animal. And as there are many parts of the body assigned to different actions and uses, nobody ought to be in doubt of the fact that there are manifold ways of dissecting the living animal.

Bk. 1. *The Method of Observing the Use of Bones and Cartilages in the Living Animal.*

In the case of the bones, for example, to deal with each point in order, we endeavour to learn from the dissection of living creatures whether they

are the best prop and support, and whether all things are attached to them and given firmness by them. For when we see some bone broken in the living animal, then we see that the whole limb that is subjected to fracture collapses and can be no longer made firm. But since this frequently happens accidentally, we do not much need vivisection in our investigation of the use of the bones. With regard to the cartilages likewise we learn, when they are broken, that they give firmness to certain parts. Indeed, in the dissection of certain joints we see what the cartilage does, even if we do not test this on the living animal.

Bk. II. *The Use of the Ligaments.*

Also the use of the ligament that unites bones is seen on dead subjects, as well as the use of the ligaments that stretch transversely across tendons. For when we divide the ligament that crosses transversely the inner side of the wrist, and draw the muscle that bends the second or third joint of the finger towards its origin, we see that it was made for the particular purpose of preventing the tendons from rising out of their position. This, however, can also be observed on a living dog, if in the course of your dissection you detach the skin from the forearm and paw, and cut with your knife the transverse ligament at the wrist, and the other ligaments which are located at the wrist on the outer side of the ulna and radius. For then when the dog of his own accord bends and extends his fingers, you will see the tendons rise out of their proper positions.

Method of Observing the Use and Function of the Muscles.

In this operation you will also examine the action of the muscles when you see them gathering into themselves and thickening where they are most fleshy, and again extending and thinning, according as they contract to pull the part, or relax and extend themselves to allow the part to be pulled in the opposite direction by another muscle, or merely cease to exert their contractile force. And this must be observed not merely in the forearm, but the skin must be detached still higher from the same dog so that the whole arm and armpit be laid bare and the nerves that pass through the armpit into the arm be exposed to view.

Bk. IV. *Use of the Nerve in the Muscles.*

Ligate one of these which you know to extend to certain muscles. But since the number and the distribution of the nerves of the dog does not quite agree with those of man, I would advise that when you are about to perform this operation on a living dog you should also have a dead one at

hand on which to learn the course of the nerves that run through the arm and the elbow, and thus discover some nerves that serve particular muscles. Examples will be those of which in man one is the third (*i.e.* median) and runs along the anterior side of the elbow joint to the forearm, the other is the fifth (*i.e.* ulnar) and passes along the posterior region of the inner epicondyle of the humerus to the forearm. For nerves of this kind are found also in dogs, and when they are ligatured at a point above the elbow joint the power of movement of the muscles that bend the fingers and the wrist is abolished. Similarly if you ligate the nerve which in the case of man is numbered fourth by me (*i.e.* musculo-spiral) and which stretches along the humerus to its external epicondyle, the power of motion of the muscles that extend the wrist and fingers will be abolished. It will also be of advantage to ligature nerves of this kind, in order that loosening the ligatures now on this, now on that nerve you may perceive that the power of motion of the muscles is restored.

Further, in a muscle the shape of a mouse (as there are many here in the forearm) you must make a longitudinal section such as to penetrate the whole body of the muscle, in order to appreciate the fact that the power of movement of the muscle is not lost in consequence of this operation. When, however, you make a transverse section in the body of the muscle, you will find the power of movement in the muscle is destroyed in proportion to the depth of the cut. And when you cut clean through the muscle you will see it gather itself together and draw back on the one side towards its place of insertion and on the other towards its place of origin But if you cut the tendon of some other muscle, you will see the muscle dragged towards its place of origin. Similarly, if you cut the head, it will be drawn towards its place of insertion. If, however, you cut both insertion and head together, the muscle will gather itself together in a ball at its own thickest part, and in its own position, at the point where it is most fleshy. And so by these endeavours you will discover the function of the muscles.

But if you decide to investigate the function of some special nerve or particular muscle, deal with that nerve or muscle as I have already instructed you how to do in the case of the arm and the forearm. And there is no need here of describing at length the best way to tie up dogs or such animals for these operations, since everybody, if he takes sufficient trouble, will find the right way, provided he is sufficiently practised in the dissection of dead bodies.* So there remains nothing to be said about the vivisection of nerves and muscles, although I shall avail myself of a later opportunity to make a few remarks about recurrent nerves.

* Readers familiar with Galen's prolix writings will understand and excuse the impatience here displayed by Vesalius.

Examination of the Function of the Nerves.

In order to see whether the substance of the nerve or the membranes that clothe it are what specially supply the animal force, a good plan is to remove the skin from the thigh, shin, and paw, and, freeing the first of the muscles (*i.e.* Glutaeus major, or Maximus) that move the thigh from its point of origin, to examine the fourth (*i.e.* Sciatic) nerve that passes into the thigh. Draw away the membrane here from the substance of the nerve, and observe how the toes of the paw, and the paw itself, still move, and how the nerve by itself still succeeds in performing the task assigned to it.

Examination of the Dorsal Medulla.

But supposing anyone should have determined to investigate the function of the dorsal medulla (*i.e.* spinal cord), intent on seeing how, when it is injured, the parts below the lesion lose sense and motion, let him secure a dog to a plank or a trunk in such a way that he presents his back and neck, so that some of the spinal vertebrae can be severed with a large knife and the dorsal medulla be exposed in that place in which it is desired to cut it. For there is nothing simpler then than to observe that the powers of motion and sense of the parts below the section are destroyed.

Bk. III. *Examination of the Veins.*

In the investigation of the use of the veins dissection of living animals is hardly necessary, since we learn sufficiently on the dead that they carry the blood through the whole body, and that any part is not nourished in which an important vein is severed in consequence of a wound. In the arteries also we hardly need vivisection ; although we may expose the artery that leads to the groin, and ligature it and observe that the part of the artery below the ligature no longer pulsates. In this way, with little trouble, it is learned that the blood is naturally contained in the arteries,* if at any time we open an artery in the living animal.

Examination of the Arteries.

But to assure ourselves that the power of pulsation is not in the artery, and that it is not the material contained in the artery that produces the pulsation but that this power depends upon the heart, in addition to the fact that we no longer observe a ligatured artery to pulsate below the

* *Cf.* Galen's treatise *An sanguis in arteriis natura contineatur*, where the question is decided in the affirmative against the followers of Erasistratus. *Cf.* also *De anatomicis administrationibus*, vii, 16.

ligature, you may also make a long incision in the artery of the groin or femur, and take a tube made of reed of such thickness that the artery can just contain it. This must be inserted in the incision in such a way that the upper part of the tube should reach to a higher point in the cavity of the artery than the upper point of incision, and that the lower part of the tube should also extend downwards below the lower point of incision. The artery must then be ligatured in such a way as to compress its walls against the inserted tube. When this is done, the blood and spirit runs out through the artery right to the foot, but the whole part of the artery below the tube no longer pulsates. But when the ligature is unloosed, the part of the artery below the tube shows the pulsation no less than that above.*

How much force is brought from the heart through the arteries to the brain we shall see later. For the moment we content ourselves with expressing our very great admiration for Galen's method of vivisection in demonstrating this point. He recommends that everything common to the brain and heart † should be severed, excepting the arteries which seek the head through the transverse processes of the vertebrae of the neck, and convey no small portion of the vital spirit into the first (*i.e.* right and left transverse) sinuses of the hard membrane, and so also into the brain. So that it is no wonder that the brain continues to function in that operation for a longer time than Galen thought likely. For the animal continues to breathe for a very long time in this operation, and moves from time to time. If, however, it runs, and so needs much spirit, it soon collapses, although the brain still receives the substance of the animal spirit from those arteries which, as I have said, seek the skull through the transverse processes of the cervical vertebrae. But in this place, where I have thought fit to give only a few passing observations on vivisection, I do not propose to recount the vivisections of Galen, rightly or wrongly celebrated. Here I shall have done quite sufficient if I complete my task by suggesting a few vivisections appropriate to each book.

Bk. V. *Examination of the Functions of the Contents of the Peritonaeum.*

And now, since the fifth book has been reached, let us just say a word or two about the organs of nutrition, the function of which we learn also as a rule in the dissection of dead bodies. For we see that the peritonaeum is the envelope of all organs enclosed in it; that the omentum, and the

* This experiment is described by Galen, *An sanguis in arteriis natura contineatur*, p. 8; *De anatomicis administrationibus*, vii, 16.

† In his *De Hippocratis et Platonis decretis*, ii, 6, Galen says that the jugular veins, the carotid arteries, and the nerves connected with them are the vessels connecting the head with the heart.

mesentery, excellently effect the branching and distribution of the vessels; that the stomach works up food and drink; and that these are brought to it through the gullet. At the same time there is nothing to stop you operating on living dogs which have taken food at longer or shorter intervals before, and thus exploring the function of the intestines. The function of the liver, however, and of the spleen, the kidneys, and the bladder, we can hardly examine better in dissecting living than dead bodies. Unless one should care to cut the spleen out of a live dog, as I have occasionally done, and have kept the dog for some days. In the same way also I have occasionally cut a kidney out; but the care of the wound is more of a nuisance than is compensated by the delight of the knowledge thus acquired. Though of course one may undertake these dissections not so much for the sake of getting to know the organs as for training the hand and learning to sew up abdominal wounds properly. This must be diligently practised on the intestines, in order that one may become accustomed to stitch them up when wounded, and replace them in the abdomen when they have fallen out. But these operations, as also dislocations and fractures of bones, which we sometimes cause in dumb creatures, help rather to the training of the hands and the establishment of a right method of cure than to the investigation of the functions of the organs.

Examination of the Organs of Generation.

To proceed, we practise vivisection of the organs of generation almost daily in the cure of hernias, and in the castration of animals, and these almost suffice for the examination of the seminal vessels and the testes. The following dissection can, however, be practised at will. Cut the substance of a dog's testis out of the envelope that immediately covers it, or else cut away the substance of the testis together with the tunic—from the seminal vessels.

Examination of Fetuses.

In operations on the living fetuses it is delightful to observe how, as soon as the fetus reaches the surrounding air, it strives to breathe. This operation can conveniently be performed on a dog or a pig, when the animal is shortly about to bear. For if you open the abdomen of the pig right to the cavity of the peritonaeum and then lay open the womb in the place where one of the fetuses lies, and freeing the placenta and the membranes from the womb, you place the fetus on the table, you will see through the transparent membranous coat how it tries in vain to breathe, and dies as if suffocated. But if you make a hole in the envelopes of the fetus and free its head from them, you will soon see it revive again and breathe nicely. Having made this experiment in one fetus, you will approach another.

This you will not free from the uterus, but you will invert for a little while the womb, as opened in the operation on the fetus already described. Then bend back and out the edges of the incision already made, until the lowest part, or the position, of the envelopes of another fetus lying next to it come into view, and until you disengage this part from the womb right up to that point where the womb joins the exterior envelope of the fetus, and where the abundant flesh (*i.e.* the placenta) is that resembles the substance of the spleen, which lies between the vessels stretching from the womb to the exterior envelope of the fetus. For in this operation the connection of the vessels must be kept intact, and the rest of the exterior envelope must be disengaged from the womb, in order that, through the transparent envelopes of the fetus, the arteries distributed through them and going up to the umbilicus may be seen pulsating to the rhythm of the arteries of the womb, and the exposed fetus trying hard to breathe. Then, on breaking and piercing the envelopes, you will see the fetus begin to breathe, and the pulsation of the arteries of the envelopes and the umbilicus coming to an end, while the arteries of the womb still pulsate together with the rest of the arteries outside it.

Bk. VI. *Examination of the Function of the Heart and of the Parts that subserve it.*

In the examination of the heart and lung we consider several points—to wit, the motion of the lung, whether the trachea takes a portion of the liquids that are drunk, the dilatation and contraction of the heart, whether there is the same rhythm of the heart and of the arteries, the way in which the venal (*i.e.* pulmonary) artery is distended and compressed, and how an animal still lives when its heart has been cut out. In observing these things, particularly to be desired would be an animal with a broad breast-bone, one that would hold the membranes that partition the thorax so far apart that, when the pectoral bone had been divided longitudinally, we could make an incision between these membranes right to the heart, without piercing the cavities of the thorax in which the lungs are contained. But since there is no animal to be found of this sort except man and the tailless ape, dissections must be practised on dogs and pigs and such animals as we can get a supply of, in such a way as to make it possible to inspect all the points mentioned above.

The fact, then, that the lung follows the motion of the thorax is to be seen from this, that if an incision be made in one of the intervals between the ribs right in the hollow of the thorax, the lung of the injured side collapses, and is no longer expanded with the thorax, although the other lung still follows the motion of the thorax. But this lung also will promptly

collapse if you make an incision on the other side also right through to the cavity of the thorax. And thus the animal, even if it continues to move the thorax for a while, will die no less than if it had been suffocated.

In performing this operation you will need to be careful to make the incision as near as possible to the upper seat of any rib, lest in directing the incision towards the lower seat you should pierce the vessels (*i.e.* internal mammary arteries) that lie along this place. For then the blood will flow out thence, and being made foamy by reason of the air drawn in and expelled through the wound, will cause you to mistake it for the lung. Those who make careless incisions of this sort mistake the foam as coming from the lung, and form the opinion that the lung expands for some time by its own innate force.

Now, in order to see the natural dependence of the lung on the thorax, cut on one side the cartilages of two or three of the middle ribs, and, having made incisions at the intervals between these ribs, bend back the ribs one by one and break them, so that you may make a convenient place through which you can see the lung of the uninjured side. For since in dogs the membranes that partition the thorax are quite transparent, it is very easy to observe through them the lung still following the movement of the thorax, and when those membranes also have been lightly pierced, to consider how the lung on that side also collapses. Before you pierce them, however, it will be helpful to seize in your hands the branches of the venal artery passing into the lung that has already collapsed, and to detach the substance of the lung from them for some distance, in order that you may learn whether they move like the heart. For the motion of the heart also is visible to you here, especially if you cut the envelope of the heart and uncover the heart from it on the side on which you are performing the operation. It will be well, however, to attempt this operation on the left side, in order of course that the right lung may still move, and in order that you may conveniently grasp the whole trunk of the venal artery in one hand.

In an operation of this sort it is also instructive to seize the base of the heart, to intercept quickly at the same time with one ligature the vessels leading from it, then to cut the heart out at a point below the ligature, and, loosening the knots by which the animal is bound, allow it to run. We have seen dogs operated on in this way, but more particularly cats, run for a considerable distance.

But you will better observe the motions of the heart and of the arteries if, immediately on binding the dog to the plank, you make an incision on both sides from the neck through the cartilages of the ribs where they join the bones, with a very sharp knife, and then from the end of one incision transversely to the end of the other you make a third incision right into the

cavity of the peritonaeum, and raising the breast-bone together with the cartilages attached thereto, and detaching the transverse septum (*i.e* diaphragm) therefrom, you bend the breast-bone up and back towards the head of the animal, and if then, cutting through the envelope of the heart, you seize the heart in one hand, and with the other hold firmly the large artery stretching along the back.

You will, however, better achieve all these results in the course of that vivisection which, as being more informative than all the rest, it has been my custom to exhibit in the schools. And, as soon as I have subjoined a few remarks on the brain, I shall describe this operation more at large, in order that others may undertake it with less trouble.

Bk. VII. *Examination of the Functions of the Brain.*

Well, then, in the examination of the brain and its functions very little is to be observed by vivisection, since in this matter, whether we like it or not, but merely out of consideration for our native theologians, we must deprive brute creatures of reason and thought, although their structure is the same as that of man. And so the student of anatomy, and he that is practised in dissecting dead bodies, and tainted by no heresy, clearly understands to what risks I should expose myself if—a thing which I should otherwise above all else gladly do—I were to make any attempt at vivisecting the brain. As far, however, as concerns sense and motion, it is possible to observe that both perish when the brain is removed. And here the same method of experimentation is to be employed as I prescribed in dealing with the nerves. Indeed the question whether the brain has sensation can be investigated in man ; for a man whose brain is cut or pressed can tell whether he feels pain or whether he has any sensation at the point where the brain is affected. This can easily be tested any day in head wounds. Again, I do not think that any one needs to be told that the skull of a dog can be fractured, and the right or left ventricle of the brain laid open, and that the animal loses the power of motion, and recovers it again when the ventricle is closed.

The Vivisection by Means of which the Final Touches are wont to be put to our Anatomical Enquiries in the Schools.

To proceed : the vivisection I promised a little while ago to describe, you should perform on a pregnant sow or bitch. It is better to choose a sow on account of the voice. For a dog, after being bound for some time, no matter what you may do to it, finally neither barks nor howls, and so you are sometimes unable to observe the loss or weakening of the voice. First, then, you must fasten the animal to the operating table as firmly as

your patience and your resources allow, in such a way that it lies upon its back and presents unimpeded the front of its neck and the trunk of its body. It is not a difficult matter to get a plank with holes in it suited for fastening the legs ; or if there are no holes in it, it is easy to put two sticks beneath the plank and bind the legs to them. Among other details, special attention must be given to the upper jaw, so that it may be firmly fastened to the plank. Do this with a chain or a strong cord fixed in front of the canine teeth, and then tied to a ring in the plank, or a hole, or any other way you find convenient, but so that the neck may be extended and the head motionless, and the animal at the same time free to breathe and cry.

Before the animal is bound in this way my custom is to pass in review for the audience, already well skilled in the dissection of dead bodies, the precise points that are to be observed in the present dissection, lest a wordy account in the middle of the operation should hinder the progress of the work, or the work even be broken off by the necessity for speech.

Examination of the Recurrent Nerves and the Destruction of the Voice by cutting them.

Then I make a long incision in the throat with a sharp razor, cutting through the skin and the muscles under it right down to the trachea, taking care lest the incision should be deflected and injure some important vein. Then I grasp the trachea in my hand, and, freeing it merely with the aid of my fingers from the muscles that lie upon it, I search out the soporal (*i.e.* carotid) arteries at its sides and the sixth pair (*i.e.* the vagus and spinal accessory nerves) of cerebral nerves stretched along it. Then I also examine the recurrent nerves attached to the sides of the trachea, and sometimes I ligature them, sometimes sever them. And this I do first on one side, in order that when the nerve is here tied or cut it may be clearly seen how the middle voice perishes, and how it altogether disappears when both nerves are affected, and how, if I slacken the knot, it again returns. You can quickly examine without much loss of blood, and very nicely hear, what a powerful outward blast the animal produces without voice when the recurrent nerves have been cut with a knife.

Then I pass to the abdomen, and with a sharp strong knife, below the cartilages of the spurious ribs and at the pointed site (*i.e.* Xiphisternum) of the breast-bone, I make a single semi-circular cut right down to the cavity of the peritonæum ; and from the middle of this incision right to the pubis I attempt another, which comes off readily if I insert the knife or razor into the cavity of the peritonaeum. In this way, by these two incisions, we shall expose the intestines and the uterus distended with the

fetuses. But we must take particular care that one of the audience put his thumb on the vessels which descend below the breast-bone and make for the abdomen. For these are the only vessels up to now from which much blood flows.

Examination of the Function of the Diaphragm.

At this point I recommend those close to the operation to apply their hand to the diaphragm and test its motion, and those at a distance to observe how the stomach and the liver are, as it were, taken up into and sent down from the cavity of the thorax.

Meantime on one side of the thorax I make a long incision down to the bones of the ribs, to about the region where the ribs degenerate into cartilage. Then along the bones of the ribs I make transverse incisions in order to free the bones to some extent from the muscles that lie upon them. And in addition, if I choose to carry out a more laborious operation, I remove the intercostal muscles in two intervals between the ribs from the inner lining of the ribs, in order that I may then, by the aid of the hands alone, tear away the rib that lies between those intervals from the inner lining of the ribs. And when it has been broken from its cartilage and bent down towards the side, a great extent of the inner lining of the ribs is exposed; and this, being transparent, affords a more or less clear view of the motion of the lungs. Then I pierce this, and it is seen how the lung on this side collapses, though the thorax continues to move just as before.

Examination of the Motions of the Lung.

But in order that this may be more plainly seen, I free more rib bones from their cartilages, opening this side of the thorax as much as possible, in order that, through the membranes that partition the thorax, the other lung, which, in the as yet uninjured cavity of the thorax, is moving nicely with the thorax, may conveniently present itself to view; and then, those membranes also being pierced, the lung on this side may also be seen to collapse and fall in, in consequence of the perforation.

Then, on the other side also, in one cut with a sharp knife I free the rib bones from the cartilages, and I cut away the diaphragm from the cartilages and breast-bone, in order that that bone, together with the cartilages, when the membranes that partition the thorax have been torn apart, may be able to be bent up and back towards the neck, and the envelope of the heart be brought into view.

Examination of the Water in the Envelope of the Heart and of the Motions of the Heart.

The envelope must be opened at once with a knife, and notice must be taken of the quantity of water it holds * and how the heart behaves. But do not long concentrate on the motion of the heart; rather come to the aid of the animal now all but suffocated by reason of the total collapse of the lungs, in order that you may then again thoroughly examine the heart and the arteries, and the fetuses contained in the womb, for as long as you choose. For up to this point the loss of blood has caused little inconvenience to the animal, provided that a member of the audience has stopped the vessels that pass beneath the breast-bone, and the breast-bone now lies † bent back against the neck, and so the vessels on account of their being bent now emit no more blood. And this would also be the case with the vessels lying along each rib, when the ribs are broken and turned down, provided that you yourself in carrying out the operation see to it that the vessels are closed for a little until they are bent.

But so that life may in some measure be restored to the animal, you must attempt an opening in the trunk of the trachea and pass into it a tube of rush or reed, and you must blow into this so that the lung may expand and the animal draw breath after a fashion; for at a light breath the lung in this living animal will swell to the size of the cavity of the thorax, and the heart take strength afresh and exhibit a great variety of motions.

Examination as to whether the Pulse of Heart and Arteries corresponds.

When the lung has been inflated once or twice, you may examine the motion of the heart as you please, by sight and touch, and take hold of the trunk of the great artery lying along the back, or in the hollow of the thorax, or beside the lumbar vertebrae, and examine it. Then nothing will be clearer to you than the rhythm of the heart and the arteries. When this has been observed for some time the lung must again be inflated; and by this device, than which none of my discoveries in anatomy pleases me more,‡ a great knowledge of the differences of the pulses can be acquired. For when the lung, long flaccid, has collapsed, a wavy, ant-like (*formicans*), and wriggling (*vermicularis*) pulse or motion of the heart and arteries is observed. But when the lung is inflated, the pulse again becomes strong

* Cf. *De Fabrica*, vi, 8, where Vesalius describes his repeated efforts to observe this phenomenon accurately in men, dogs, and pigs.

† The text has *jaciat*. I translate *jaceat*.

‡ This is the only experiment in this chapter which Vesalius claims to have originated.

and rapid, and exhibits wonderful variations. Indeed, to state the fact once for all, the variations are of such a sort that I am accustomed by means of them to exhibit to my students in the best manner the nature of all pulses.

Examination of Fetuses.

But I delay no longer on the examination of these things on account of the fetuses, but in some horn of the womb of dog or pig I make an incision over a fetus, penetrating to its exterior envelope. Then from the torn uterus I take the fetus together with its envelope, and breaking the exterior envelope, I show through the interior, which is very transparent, how the fetus tries to breathe, and how nicely it draws breath when the interior envelope also is broken. Then I expose the next fetus as far as I can, without detaching the uterus in any place from the exterior envelope, in order that here the nature of the vessels of the fetus may be examined according to the method already prescribed for operating on the living fetus.

Examination of the Motions of the Venal Artery and of the Arterial Vein.

When I am engaged on this, if I see to it that the lung be inflated from time to time, the motion of the heart and arteries is not yet passed observation, but for quite a long time the life of the animal can be restored, and the motions of the auricles of the heart can also be readily examined, as also can those of the venal artery and the arterial vein. And if it be not sufficient to touch them near to the heart, in some segment of the lung I pluck the substance of the lung, with my nails, away from the vessels, and allow to be observed what is to be noticed here. Then I open the right ventricle of the heart, by which it is established how the heart, even when the ventricle is opened, none the less moves. The left ventricle, moreover, being opened together with the former, or the middle of the heart being removed by a transverse section, I recommend the audience to observe that the motion of the auricles of the heart is not yet stilled.

Then, if before the operation we have given drink stained with some colour to the animal, and if it has taken various foods one after the other, I examine what sort of moisture is met with in the branches of the trachea of the lung, and what is the arrangement of the foods in the stomach.

By this dissection I put the finishing touch in the schools to the whole course of anatomical study, as I now with the same bring to an end my account of the mechanism of the human body.

End of the Seventh and Last Book.

SOUTH AFRICAN BRYOPHYTA. FURTHER NOTES.

By Dr. T. R. Sim, Maritzburg.

Since I last published, many localities have been added, mostly from West and South-West districts, Transvaal, and Rhodesia. These have been sent mostly through the South African Museum, the Bolus Herbarium, the National Herbarium, and the Natal University College, or privately.

Among other collectors may be mentioned Dr. Barnard, Miss Stephens, M. A. Giffen, Mr. Primos, Dr. Marloth, C. Thorne, Prof. Compton, Mr. Hay of the Fishery Survey, and Mr. Dinter, all from the West or South-West; Dr. Muir and Miss Duthie from the Riversdale and Knysna Region; Dr. Bews from about George; Mr. James Leighton from Kingwilliamstown; Mr. Bayer, Mr. J. M. Sim, Mr. G. W. Sim, and Mr. van der Plank from Natal; Miss Young, Miss Ottley, and Mrs Moss from the Transvaal; Mr. Eyles, Mr. Henkel, and Mr. James Sim from South Rhodesia; Miss Pocock from Angola and Northern Rhodesia; and Mr. W. Leighton from Kenia. Thus all parts of South Africa may be said to be equally well known, and while there is no necessity to restate localities of common kinds collected, it has been usual to add localities which bring in districts or provinces previously unreported, or even localities of rare kinds. All noted are additions to former list, except that those frequent in all districts have been marked by an asterisk. But there is little change in the general distribution; the Table Mountain species have been found to extend across into the Hottentots' Holland, and Swellendam Mountains; the western Karroo species have been found to extend more widely than at first appeared; and the same applies to the species peculiar to other regions, but on the whole the proportions remain much as they were; xerophytic kinds remain xerophytic, forest kinds remain forest kinds, and aquatic kinds are as formerly, only more variable in form.

Numbers and pages are as those given in "Bryophyta of South Africa."

2. *Riccia coronata* Sim. Cape, W., Stellenbosch (Miss Duthie).

3. *R. natalensis* Sim. Transvaal, Premier Mine (Dr. Pole-Evans).

4. *R. albo-marginata* G. L. N. Rhodesia, Matopos and Bulawayo (Sim).

8. *R. limbata* G. L. N.*

9. *R. concava* G. L. N. Natal, Vryheid (Sim); Transvaal, Vereeniging

(J. B. Davy); S. Rhodesia, Rhodes' Grave (Sim); Port. E. Africa, Magude (Sim).

10. *R. bullosa* Link. Cape, W., Hex River Mountains (Miss Stephen).

12. *R. crystallina* Linn.*

— *Ricciella Rauteneni* Step. S.W. Africa, Hereroland (*Fide* Dr. Hans Schinz).

14. *Riccia purpurascens* L. and L. Pug. Cape, E., George (Wager). Miss Duthie was working on this on Stellenbosch Flats in 1928 and in cultivation from Knysna and expected to make 2 species, but so far as I am aware has not published concerning them yet.

16. *Targionia* * (should be *hypophylla*); also Rhodesia, Basutoland, O.R.C., and Okiep, Namaqualand.

17. *Plagioschasma capense* Sim. Natal, Taylors (Dr. Bews); Olivershoek (Miss Edwards).

18. *P. tenue* St. O.F.S., Venterstad (Mrs. B. Rogers).

19. *P. rupestre* St.*

— *Exormotheca megastomata* Marq. (in Kew Bulletin, xxv), much paler, scales not ciliated; thalli 8–11 mm. long, 5–6 mm. wide, 4 mm. deep; stomata 2 mm. high, whitish, forming a surface stratum of empty cells; second layer small, chlorophyllose; third layer small. Middelburg, Transvaal (Dr. Pole-Evans).

22. *Reboulia hemispherica* Raddi. Rhodesia, Goromanzi (F. Eyles).

23. *Grimaldia capensis* St.*

25. *Fimbriaria muscicola* St.* And S.W. Africa.

26. *F. marginata* Nees,* mostly at fairly high altitudes.

27. *F. Wilmsii* Steph. Add S. Rhodesia and Swaziland.

28. *Lunularia cruciata* Dum. Cape, Giffen (Miss Duthie); Natal, Knoll (Sim); Transvaal, Johannesburg (Miss Young, Miss Ottley, Miss Auret).

29. *Dumortiera hirsuta* R. Bl. and N. East Africa (W. Leighton).

30. *Marchantia tabularis* Nees. Numerous localities, all Cape, W., and S.W.

31. *M. Wilmsii*, St. Very numerous localities, all east of Uitenhage, including Swaziland and S. Rhodesia.

38. *Pallavicenia Lyellii* Hk. Also Swaziland.

40. *Symphogyna podophylla* M. and N. Also Cape, W., Stellenbosch (Miss Duthie); Cedarberg (Miss Doidge); S. Rhodesia, Inyanga (Henkel).

42. *Fossombronia tumida* Mitt. Cape, W., Cape Town (Wager); Kirstenbosch (Miss Bottomley).

43. *F. pusilla* Dum. Also O.F.S. and Kimberley (Cape).

48. *F. Ecklonii* Spr. Add S. Rhodesia and Port. E. Africa.

49. *F. caffraria* St.* Except S. Rhodesia.

50. *F. sylvestris* Sim.*

52. *F. squarrosa* Nees.*

55. *F. affinis* Nees. Transkei (Cape, E.), Natal, and Transvaal.

56. *F. natalensis* Sim. Cape, E., Hogsback (Miss Young).

58. *F. serrata* Got. Natal, Zwart Kop and Van Reenen (Sim); Transvaal, Hautbush (Rehmann).

60. *F. capensis* Got. Natal, Isipingo (Sim).

61. *F. brunnea* Syn. Hep. Cape, Zonder Einde Peak and Garcias Pass, Riversdale (C. Thorne).

63. *F. Lindenbergii* Got. S. Rhodesia, Umtali (Eyles).

65. *Cololejeunea minutissima* Schf. Transvaal, Wonderboom (Miss Bosman).

70. *Archilejeunea xanthocarpa* St. Transvaal, Pisanghoek (Miss Bosman).

71. *A. rotundistipula* Step. S. Rhodesia, Inyanga (Eyles).

81. *Microlejeunea gracillima* Pears. Cape, E., Storms River (Burtt-Davy). Natal, Nels Rust and Greytown (Sim); Eshowe (v. d. Plank). Transvaal, Hautbosh.

82. *M. Helenae* Pears. Add S. Rhodesia, Salisbury (Eyles).

84. *Eulejeunea capensis* St. Cape, W., Table Mountain (Sim); Natal, Bulwer (Bayer); S. Rhodesia, Mazoe (Eyles).

85. *E. elobulata* Sim. Natal, Maritzburg and Mont aux Sources (Sim).

91. *E. caespitosa* Steph.*

100. *Madotheca capensis* Got. Also Port. E. Africa (Swynnerton 6016).

104. *Schistochila alata* Schiff. Transvaal, Entebeni (P. Watson).

112. *Alobiella heterophylla* Step. Natal, Edendale, Town Bush, Lidgetton (Sim); Eshowe (v. d. Plank); Transvaal, Rietfontein (Wager).

114. *Calypogeia fusca* St.* Except Rhodesia.

115. *C. bidentata* Nees. Transvaal, Rietfontein (Wager); S. Rhodesia, Victoria Falls (Miss Duthie); E. Africa (W. Leighton).

117. *Bazzania convexa* Mitt.* Except Transvaal.

118. *B. adnexa* Sim. Transvaal, Kaapsche Hoek (Wager).

119. *B. radicans* Sim. Cape, W., Bain's Kloof (Primos).

120. *B. pellucida* Sim. Cape, W., Garcia's Pass (Dr. Muir). Page 83, in synopsis, *re* 123, *cells* should be *leaves*.

122. *Cephalozia bicuspidata* Dum.* Except Rhodesia.

123. *C. atro-viridis* Sim.* And Port. E. Africa.

125. *C. Kaieri* Pears.* Except Transvaal and Rhodesia.

130. *C. Pillansii* Sim. Cape, W., Bain's Kloof (Primos); Hermann's Hoek, Riversdale (Dr. Muir).

133. *Lepidozia cupressina* (Ldbg.). Cape, W., River Zonder Einde (C. Thorne); Wilde Paarde Mountains, Genadendal (T. P. Stokoe); Swellendam Mountains (Dr. Barnard); also in Kenia.

134. *L. truncatella* Nees.* Except S. Rhodesia.

135. *L. natalensis* St. Natal, Mont aux Sources (Sim).

137. *L. capillaris* Ldbg. Cape, W., Swellendam (Dr Muir) ; Transvaal, Kaapsche Hoek (Wager).

139. *L. bicruris* Step.*

141. *Jamesoniella Rehmannii* Steph. Cape, E., Eveleyn Valley and Perie (T. R. Sim).

142. *Notoscyphus vermicularis* Step. Basutoland and Transvaal.

143. *N. lutescens* Mitt. Cape, W., Natal, and Transvaal.

145. *Nardia Jackii* Steph. Transvaal, Magaliesbergen (Mogg) ; Pienaars Poorte (Wager).

147. *Gongylanthus renifolius* Steph. Cape, W., Papanjaisberg (Miss Duthie).

152. *Chiloscyphus Rabenhorstii* St. Cape, W., French Hoek Pass.

154. *Lophocolea bidentata* Nees.* And Kenia.

156. *L. muricata* Nees. Cape, W., Montagu Pass (Miss Taylor) ; Natal, Deepdale (Sim).

160. *Tylimanthus africanus* Pears. Natal, Dargle Bush (Sim).

163. *Leptoscyphus Gottscheanus* Sim. Cape, W., Stellenbosch (Miss Duthie) ; Natal, Inanda (Rehmann).

167. *Plagiochila sarmentosa* Lehm. Cape, W., Swellendam (Miss Duthie) ; Hermanus (Miss Garahedian and also Miss Stephen) ; Natal, Zwart Kop (Sim).

168. *P. heterostipa* St. Cape, W., Devil's Peak ; Natal, Rosetta (Sim).

169. *P. corymbulosa* Pears.* And Kenia.

172. *P. crispulo-caudata* Gott. Cape, W. and E.

173. *Marsupella aurita* Sim. A somewhat similar plant has been sent from Inyanga, S. Rhodesia, by Mr. Henkel.

177. *Anthoceros Bolusii* Sim.*

— The genera of mosses are described by Brotherus in Pflanzenfam. xi.

Page 129. The S.A. species of *Sphagnum* are included in *S. palustre* Linn in Flora Capensis Thun. ed. Schulles, 1923, from Taffelberg.

181. *Sphagnum capense* Horns, with almost enclosed capsules, smaller than European forms, was found in Diamond Stream, Kirstenbosch, by Miss Dora Weintraub, 29th November 1929. Capsules abundant, 1–2 per plant, evident when fresh, afterwards not evident, and overtopped by 3–4 bracts just like leaves, or larger and more pointed ; capsule globose, brown, lid circular, pseudo-pod not seen, but spores abundant ; somewhat three-angular by compression. Seta not seen, and androecia not seen on same plant. The capsule may be a specific character.

181. *S. capense* Horns. var. *multiporosum* Warnst. is recorded by Dixon and Wager from Belfast, Transvaal.

183. *S. panduraefolium* C. M. Cape, W., French Hoek Pass (Miss Stephens).

185. *S. Rehmannii* War.* Except Rhodesia.

186. *S. truncatum* Horns. Cape, W., Muisenberg, floating (Dr. Marloth). Groote Rivier, Hermannsburg (Fishery Survey).

— *S. fimbriatum* Wils. is recorded fertile from George by Dixon and Wager (Trans. Roy. Soc. (S.A.), xviii, 3, p. 248).

190. *Psilopilum afro-laevigatum* Dixon. Natal, Highbury, Polela (Sim); Basutoland, Qacha's Nek (K. Wilson).

193. *Pogonatum capense* Jaeg.* And from Madagascar.

195. *Polytrichum piliferum* Schreb. Cape, W., Natal, Bulwer (Bayer); Zwartberg, Prince Albert (Miss Pocock); Garcia's Pass (Dr. Muir); Stellenbosch Flats (Miss Duthie); Zuurbrak Peak, Swellendam Nek, and Cedarberg (Dr. Barnard); near Whitehills (Prof. Compton).

198. *Archidium alternifolium* Sch. Cape, S.W., Top of Bokkeveld Hill, Clanwilliam (Giffen).

199. *A. capense* Horns. Transvaal, Haaskloof (Wager).

— *Ditrichum hymenodontium* Dixon is near *D. flexifolium*, but has small, erect, symmetric capsules and anastomosing peristome. Described and figured Trans. Roy. Soc. (S.A.), xviii, 3, p. 249. Benoni, Transvaal (Wager).

— *Trematodon divaricatus* Br. Eur. (near *T. flexifolius*) is maintained by Dixon as having neck shorter than or equal to capsules, *T. flexifolius* having neck twice as long as capsules. He also places *T. ligulatus* Rehm., 22, in *T. africanus*, and maintains *T. intermedius* W. and D., which I united with *T. paradoxus* Horns., as he finds from Ecklon's specimen in Hb. Schimper that *T. paradoxus* has the leaf subula very broadly ligulate and obtuse, with very lax cells, whereas *T. intermedius* in all its forms has narrow subula and small cells.

220. *T. pallidens* C. M. Natal, Buccleuch and Zwart Kop (Sim).

221. *T. flexifolius* C. N.* Except Cape and Rhodesia.

225. *Dicranella minuta* Jaeg. Cape, Montagu Pass (Miss Taylor).

226. *D. subcompressa* pl. Cape, W., Garcia's Pass (Dr. Muir); Natal, Edendale and Town Bush (Sim); Eshowe (v. d. Plank).

227. *D. subsubulata* Jaeg. Except Cape.

235. *Leucoloma Rehmannii* Rehm.*

236. *L. chrysobasilare* Jaeg. (rare). Cape, E., Eveleyn Valley, Perie, and Dohne Hill (Sim); Transvaal, Rosehaugh (Sim); Lechlaba (Rehm.); Woodbush (Wager).

238. *Campylopus griscolus* Par. Natal, Zwart Kop, and Highbury, Polela (Sim).

239. *C. trichodes* Lor. Add many western and Zululand localities.

244. *C. leptotrichaceus* Par. Add many localities except in Cape, E., and Rhodesia.

245. *C. chlorotrichus* C. M., form *orthophylla*, is from Inanda, Natal (J. M. Wood).

250. *C. purpurascens* Lor.* And Basutoland.

251. *C. chlorophyllosus* Jaeg. Many localities in all areas and Basutoland.

252. *C. longescens* Broth. Cape, W., Winterhoek, Kleinpoort, and Zuurbrak Peak, Langebergen (Dr. Barnard); Table Mountain (Dr. Bews).

253. *C. atroluteus* Par. Basutoland, Qacha's Nek (K. Wilson).

257. *C. nanus* C. M. Cape, W., Whitehills (Prof. Compton); Garcia's Pass (Dr. Muir); Natal, Polela, Maritzburg and Polela (Sim).

— *Leucobryum isleanum* Besch. is included by Thériot from Shilouvane, Transvaal (Junod).

259. *L. perfalcatum* Sim. Natal; add Buccleuch and Dargle Bush (T. R. Sim); Blinkwater (J. M. Sim).

260. *L. madagassum* Besch. Natal, Ngomi (forester there).

261. *L. Gueinzii* C. M.* Miss Pocock found this and *Camp. inchangae* floored stretches of dry leguminous forest just inside the Angola border, 15° south from N. Rhodesia.

263. *Octoblepharum albidum* Hedw.*

Family Archifissidentaceae (new Family).

Nanobryum Dummeri Dixon is found by Potier de la Varde to have equitant leaves, more or less like *Fissidens*, and to have the cells elongated as in the margins of some *Fissidens* species, and also to have the protenema massed together side by side and united so as to form a thallus, as was found by Wager. It consequently is worth a new family, placed before Fissidentaceae, and is probably of an earlier type. Potier de la Varde was himself misled by it at first, and described it as *Anisothecium pallidisetum* P. de la V. in "Mousses nouvelles d' l'Afrique tropicale française," 4th Note, Bull. Soc. Bot. Fr., t. lxxii, 1926, pp. 377–386, figs. 25–28, but Dixon's name, being earlier, holds. It is placed in new family Archifissidentaceae in "Mousses de l'Oubangui," 1828 (Archives de Botanique), t. 1 (1927), Memoir 3, where it states that Dixon admits that his measurements of spores were wrong, and that they should be 15–15μ.

Fissidens. In Annales de Cryptogamie exotique, July 1924, Mons. R. Potier de la Varde gives interesting details of vegetative propagation in *Fissidens* on the leaves of some West African species, and in the same journal (December 1929) he remarks upon the groups of *Fissidens*, especially *Pycnothallia*.

282. Later he examined my *F. brevisetus* and found it identical with the earlier *F. scleromitrius* (Besch.) Broth. from Madagascar, and he also has it from Oubangui. He finds that it is the only really gymnostomous species of *Fissidens*, and, moreover, that the cell structure is different from any of the species of § *semilimbidium*, and he makes a new subgenus, *Moenkemeyera*, of it.

270. *F. laxifolius* Horns. he found to be *F. pycnophyllus*. Dixon in Trans. Roy. Soc. (S.A.), xviii, 3, p. 251, makes a new species (described and figured) :—

— *F. aciphyllus* Dixon (§ *Reticularia*) having cells elongate, nerve reaching the leaf-apex and joined with the stout border forming a cuspidate point. Capsule small, curved, inclined, or cernuous. Port St. Johns (Wager). Also he describes and figures :—

— (? § *Aloina*) *F. pectinidens* Dixon, near *F. calochlorus* Dixon, but not so green leaves, without border, narrower at apex and longer point ; cells lax and pellucid. Seta 5 mm. high ; peristome teeth cristate. Port St. Johns (Wager).

266. *F. pycnophyllus* Hedw.* And Rhodesia.

271. *F. parvilimbatus* Sim. Transvaal, Magaliesberg (Miss Bosman).

273. *F. pseudoserratus* Jaeg. Natal, Newcastle (Dr. Bews) ; Eshowe (v. d. Plank).

275. *F. erosulus* Par. Natal, Knoll, Hilton Road (Sim) ; Transvaal, Silverton and Pelindaba (Miss Bosman).

277. *F. zuluensis* B. and B. Natal, Signal Hill, Eshowe (v. d. Plank).

281. *F. submarginatus* Bruch. Cape, E., Port St. Johns ; Transvaal, Pretoria and Pelindaba (Miss Bosman).

289. *F. cuspidatus* C. M. Transvaal, Belfast (Wager) ; Zuitpansberg (Miss Bosman).

292. *F. rufescens* Horns. Cape, W., Clanwilliam (Giffen).

300. *F. fasciculatus* Horns. Cape, W., Garcia's Pass (Dr. Muir) ; Kleinpoort.

301. *F. plumosus* Horns. Many localities in western area ; a few in each eastern area.

305. *Grimmia apocarpa* Hedw. Cape, W., Sneeuwberg, Cedarberg (Thorne) ; Basutoland, Qacha's Nek (K. Wilson) ; Transvaal, Rosehaugh and Pilgrims Rest (J. M. Sim).

312. *Rhacomitrium nigro-viride* Par. Cape, W., Waaihoek, Goudeni Road (Dr. Barnard). (Fertile.) Capsule ovate, large, small-mouthed, more cylindrical when dry.

313. *R. crispulum* Hk. and W. Natal, Greytown (Sim).

316. *Ptychomitrium cucullatifolium* Jaeg. O.F.S., Philippolis (Nel) ; Basutoland, Leribe (Madame Deterlin).

322. *P. marginatum* W. and D.*

324. *Phascum leptophyllum* C. M. Cape, E., King William's Town (*fide* Wager).

325. *P. peraristatum* C. M. is recorded (Trans. Roy. Soc. (S.A.), xviii, 3, p. 253).

— *Pottia subplano-marginata* Dixon is described and figured in Trans. Roy. Soc. (S.A.), xviii, 3, p. 253. Leaves between *P. afrophaea* and *P. Macowaniana*.

327. *P. Macowaniana* C. M. Cape, E., King Williams Town (Wager).

328. *Pterygoneurum Macleanum* Warnst. Cape, W., Riversdale (Dr. Muir).

330. *Hyophila cyathiformis* Sim.*

331. *H. atrovirens* Jaeg. S.W. Africa, Nanunkloft, near Lüderitzbucht (Dr. P. Range, 1540).

335. *Weisiopsis plicata* Broth. S.W. Africa, Windhoek (Noel).

— *W. pulchriretis* Dixon (new species), described and figured in Trans. Roy. Soc. (S.A.), xviii, 3, p. 252. May be a new genus. Capsule not plicate; leaves spathulate; cells large, slightly mamillate on the back. National Park, Natal (Wager).

337. *Tortula reticularia* Broth. Cape, W., Khamieskroon, Namaqualand (C. Thorne, S.A.M.H. 48766).

339. *T. ruralis* Ehrh. O.F.S., Philippolis (Lyle). Basutoland, Morija (Dr. Stoneman).

— *T. brevitubulosa* Broth. Peristome tube very short, otherwise near *T. erubescens* Broth. Natal, Goodoo Pass (Wager 742), in Trans. Roy. Soc. (S.A.), xviii, 3, p. 253.

343. *T. muralis* Hedw. Cape W., Elgin (Sim); Stellenbosch (Garside); Clanwilliam (Giffen); Outja, S.W. District (Dr. Barnard); Montagu Pass (Rehm); Cape, E., George (Dr. Barnard).

345. *T. deserta* Broth. Cape, W., Kradouw, Clanwilliam (Giffen).

346. *T. irregularis* Sim. Natal, Kettlefontein and Polela (T. R. Sim); S. Rhodesia, Zimbabwe (Miss Garabedian, July 1930).

347. *T. brevimucronata* Broth. Many new localities, all Natal.

349. *T. atrovirens*, Lindb. S.W. Africa, Kamanijab (Dr. Barnard), almost like *Pterygoneurum*; Natal, Cathkin and Zwart Kop (Sim).

352. *Barbula torquatifolia* Geh. Thériot in sending Mr. Dixon a specimen from Nyasaland says the nerve structure shows it to be a *Tortula*.

353. *B. afro-fontana* Broth. Cape, E., Port St. John's, in water (Wager); Transvaal, Lydenburg (Wager).

354. *B. elongata* Dixon should read " present everywhere there and," *i.e.* present only at Victoria Falls.

356. *B. Stuhlmannii* Broth. Transvaal, Frieteges Farm, near Erasmus Drift (Miss Bottomley).

358. *B. trichostomacea* C. M. Cape, E., Grahamstown (Dyer); Transvaal, Frieteges Farm (Reinecke).

362. *Tortella obtusifolia* Dixon. Cape, E., Shark's River, Port Elizabeth (Sim 9054).

363. *T. eutrichostoma* Broth. Cape, E., Hogsback Mountains (Miss Young); Natal, Bulwer (Bayer).

364. *T. caespitosa* Limp.*

366. *T. brachydontium* Br. Many localities; also Kenia.

368. *T. tortuloides* S. and L. Natal, Rosetta and Polela (Sim).

369. *T. Rehmannii* Sim. Natal, Maritzburg, Polela, and Kettlefontein (Sim).

374. *Didymodon subfontanus* Dixon. Transvaal, Pelindaba, Pretoria District (Miss Bosman).

376. *D. afro-rubellus* Dixon. Natal, National Park (Wager). Transvaal, Pretoria (Sim).

378. *Oreoweisia erosa* C. M. Recorded from Belfast, Transvaal (Wager), in Trans. Roy. Soc. (S.A.), xviii, 3, p. 249. "The short but abrupt and distinct neck is a marked character." Dixon places it in *Dicranaceae*.

381. *Triquetrella tristicha* C. M. Cape, W., Hottentots' Holland Mountains (Miss Stephen); Riversdale (Dr. Muir); Cape, E., Keurbooms River (Dr. Barnard); Uitenhage (James Sim).

382. *Weisia crispata* C. M. var. *brachycarpum* Dixon is distinguished from *W. crispata* by its short turgidly elliptic capsule and the entire absence of a peristome. A New Zealand var. *gymnostoma* is very close. Transvaal, Woodbush (Wager); Cape, W., Cape Peninsula (Pillans).

— Dixon holds that *W. oranica* C. M. is distinguished by its dioecious inflorescence, stout nerve, and calcareous habit. Cape, E., Port St. John's (Wager).

383. *W. viridula* Hedw. Natal, Vryheid (Sim); Signal Hill, Eshowe (v. d. Plank 217); Transvaal, Waterkloof Ravine, Pretoria (Miss Bottomley).

384. *Tetrapterum capense* Jaeg. Cape, W., Clanwilliam (Giffen).

385. *Hymenostomum humicolum* Paris. S. Rhodesia, Salisbury (Eyles, 3333); Zimbabwe (Sim); Ironmask Hill, Mazoe (James Sim).

387. *Hymenostylium crassinervium* Br. and Dix. Cape, W., Skeleton Ravine, Table Mountain (Mrs. Bolus 14826); Outio, on limestone (Dr. Barnard, 33130), and Natal.

388. *H. ceratodontium* Broth. Cape, W., Table Mountain (Dr. Bews); Natal, Cathkin (Sim); Eshowe (v. d. Plank 154); O.F.S., Bloemfontein

(Lyle); Philippolis (Prof. Potts); Basutoland, Qacha's Nek (K. Wilson); Transvaal, near Kiosk, Pretoria (Miss Bosman).

391. *Gymnostomum calcareum* Br. Germ. Cape, W., Taffelberg, Cedarberg (Dr. Barnard); Natal, Eshowe (v. d. Plank); Transvaal, Magaliesberg (Mogg); Lime Quarry, Rosehaugh (T. R. Sim).

392. *G. dimorphum* Sim. Additional Transvaal localities.

393. *G. Pottsii* Sim. Natal, Eshowe (v. d. Plank 227).

394. *G. lingulatum* Sim. Sim 7186 from Kakazella Mountain (Cape, E.) is now found to belong here, and has typical leaves and lateral gymnostomous short oval capsules on half-inch seta and perichaetal leaves not different from others. Also Sim 10313 from Winter's Kloof, Natal.

395. *Calympyres rhodosiae* should be *C. victoriae* Dixon. S.A. Jour. Sc., xviii, p. 308.

396. *Syrrhopodon pomiformis* C. M. "The commonest moss in the Langeberg" (Dr. Muir).

398. *S. obliquirostris* C. M. "Teeth short, red, wide at the base, suddenly narrowed into a long beak." Cape, W., Table Mountain (Sim); Cape, E., George and Langebergen (Dr. Barnard); Natal, Meyer's Hoek, Nels Rust and Buccleuch (Sim).

400. *Encalypta ciliata* Hoffm. Natal, Upper Tugela (Dr. Bews).

403. *Zygodon runcinatus* C. M. Cape, W., Riebeck's Kasteel and Tulbagh Valley (Dr. Barnard). Prof. Malta describes and illustrates small gemmae on *Z. runcinatus*.

404. *Z. trichomitrius* H. and W. Cape, E., Perie (T. R. Sim); Natal, Polela and Cathkin (Sim). Prof. Malta keeps *Z. erosus* separate but illustrates gemmae, and also maintains *Z. cernuus* C. M. and illustrates gemmae.

407. *Z. Dixoni* Sim. Prof. Malta says it belongs to the *bryoides* group of *Z. pungens* C. M. and stands next to *Z. humilis*.

408. *Z. transvaaliensis* Sim. Natal, Polela (Sim). Included by Prof. Malta in *Z. intermedius* Br. Eur.

410. *Ulota Eckloni* Horns. I have now seen the type and it is undoubtedly *Ulota*, and there is no reason to doubt the description or locality. Prof. Malta deals with it in his pamphlet. I did not see the apophysis nor the cilia, the calyptra or the lid.

413. *Orthotrichum glaucum* Spreng. Cape, W., Citrusdahl (Dr. Barnard); Cape, E., Knysna (Miss Duthie); Graaffreinet (Maclea).

416. *O. transvaaliense* Sim. Natal, Graytown (Sim 8434); Transvaal, Westcliffe Kopje, Johannesburg (Miss Young).

417. *O. subexsertum* C. M. Many additional localities in Cape, W., and to Oudtshoorn.

419. *Macromitrium pulchellum* Brid. Natal, Zwart Kop, Town Bush, Polela and Lundys Hill, Umkomaas (Sim); S. Rhodesia, Umtali (Eyles).

421. *M. Mannii* Jaeg. Cape, E., George (Dr. Barnard); Natal. Many Natal localities.

422. *M. secundum* C. M. Natal, Knoll, Hilton Road (Sim).

423. *M. rugifolium* C. M. Natal, Zwart Kop (Sim).

427. *Schlotheimia rufo-aeruginosa* C. M. Cape, W., Table Mountain (Dr. Barnard); Cape, E., Knysna (Miss Duthie); Natal, Zwart Kop, Maritzburg, Polela and Gillitts (Sim); Eshowe (v. d. Plank).

429. *S. ferruginea* Brid. Cape, W., Garcia's Pass (C. Thorne); Natal, Gordon Falls, Edendale, and Nels Rust (T. R. Sim).

430. *Eustichia longirostris* C. M. Basutoland, Leribe (Madame Dieterlin).

432. *Oedipodiella australis* Dixon. Natal, Baynesfield, Nels Rust (T. R. Sim).

433. *Chamaebryum pottioides* Thér and Dixon. Cape, W., Khamieskroon, Namaqualand (C. Thorne).

436. *Ephemerum sessile* Br. Eur. Natal, Sweetwaters (Sim 8186).

— *Ephemerella nervosa* Dixon (n. sp.) seems to be much like *E. sessile* Br. Eur. It is described (Trans. Roy. Soc. (S.A.), xviii, 3, p. 254) as having aristate nerve in perichaetal leaves, and smaller spores, narrower cells, and curcullate calyptra. King William's Town (Wager).

439. *Physcomitrellopsis africana* W. and B. Cape, W., Bak River (Dr. Barnard).

441. *Goniomitrium africanum* Broth. S.W. Africa, Cayimeib (C. Thorne); Transvaal, Pretoria (Wager).

442. *Physcomitrium spathulatum* C. M. Many additional localities in each area.

443. *Entosthodon Rottleri* C. M. Cape, E., Summit of Zuurberg Range, Steynsburg, Alexander, as *F. campylopodoides* Br. (Wager, Trans. Roy. Soc. (S.A.), xviii, 3, p. 255); Fort Murray and Perie (Sim); O.F.S., Fauresmith (Dr. Pole-Evans); Natal, Vryheid and Polela (Sim); Eshowe (v. d. Plank 99).

444. *E. urceolatus* Mitt. O.F.S., Philippolis (Lyle).

— *Funaria rufinervis* Dixon (n. sp. in Trans. Roy. Soc. (S.A.), xviii, 3, p. 254). Peristome present, capsule erect, leaves narrowly acuminate. National Park, Natal (Wager).

447. *E. Dixoni* Sim. S. Rhodesia, Matopos (as *F. longicollis* Dixon), (Wager 900).

449. *E. marginatus* C. M.* Var. *obtusata* Sim. National Park, Natal (Wager).

452. *Funaria hygrometrica* Sibth. Thériot maintains *F. gracilescens* Sch. M. S. from Shilouvane (R. Junod) in 1929.

455. *Leptotheca Gaudichaudii* Schw. Natal, Giant's Castle (R. E. Symons).

457. *Bartramia substricta* C. M. Many localities, all Cape. Basutoland, Qacha's Nek (K. Wilson).

460. *B. sericea* Horns. Cape, W., Hottentots' Holland Mountains (Miss Stephen); Cape, E., Langeberg Pass, Oudtshoorn (Dr. Bews); Kimberley (Miss Wilman); Natal, Tweedie (G. W. Sim); Polela (T. R. Sim); Basutoland, Qacha's Nek, 7000 feet (K. Wilson).

461. *B. compacta* Horns. Cape, W., Stellenbosch (Miss Duthie); Zwartberg, Prince Albert District (Miss Pocock).

462. *Bartramidula comosa* Hpe. and C. M. Natal, Jakals Kop and Zwart Kop (Sim); Basutoland, Leribe (Junod).

463. *B. globosa* Broth.*

464. *Philinotis scabrifolia* H. and W. Cape, W., Clanwilliam (Giffen); Groot Drakenstein (Primos).

466. *P. androgyna* Jaeg. Many localities in all areas. Basutoland, Qacha's Nek, 7000 feet (K. Wilson).

468. *P. laxissima* Br. Jav. Natal, Rosetta, Vryheid, and Krantz Kloof (Sim); Eshowe (v. d. Plank); Basutoland, Qacha's Nek (K. Wilson).

469. *P. Dregeana* Jaeg. Cape, W., Skeleton Gorge (Dr. Bews); Natal, Eshowe (v. d. Plank).

470. *P. obtusata* C. M. Cape, E., Hogsback (Miss Young); Basutoland, Qacha's Nek (K. Wilson); Transvaal, Pretoria (Miss Bottomley). The figure on page 309 should be *P. obtusata* instead of *P. cavifolia*.

471. *P. imbricatula* Mitt.* Except Rhodesia.

473. *P. afro-fontana* Par. Many localities in all districts except S. Rhodesia.

474. *P. africanas* Par. Cape, W., Table Mountain (Dr. Bews); Natal, Karkloof (Prof. Reid).

475. *Breutelia afroscoparia* C. M. Cape, W., Groote Drakenstein Mountains (Primos).

476. *B. aristaria* Broth. Cape, W., Garcia's Pass (Dr. Muir); Montagu Pass (Rehm. 184).

481. *Mielichhoferia transvaaliensis* C. M. Natal, National Park (Wager); Transvaal, Witpoortje (Miss Mackay); Belfast (Wager).

488. *Brachymenium variabile* Dixon. Natal, Eshowe (v. d. Plank 4 and 141).

490. *B. dicranoides* Jaeg. Natal, Maritzburg, Hilton Road, and Vryheid (Sim); Eshowe (v. d. Plank).

492. *Webera nutans* Hedw. Cape, W., Cape Town (Tyson), Zwartberg Pass (Dr. Barnard).

498. *Anomobryum promontorii* C. M. Cape, W., Stellenbosch (Miss Duthie); Natal, Bulwer (Bayer); Transvaal, Pretoria (Mogg).

503. *Bryum condensatum* C. M. Cape, W., Clanwilliam (Giffen);

Bain's Kloof Pass (C. Thorne); Simon's Berg (Pillans); Cape, E., Port Elizabeth (T. R. Sim); Natal, Zwart Kop (Sim 9315).

504. *B. rigidicuspis* Dixon. Natal, Maritzburg (Sim); O.F.S., Philippolis (Lyle).

505. *B. aulacomnioides* C. M.* Except Rhodesia. var. *limbatum*. Natal, Deepdale (Sim 10339); Basutoland, Leribe (Madame Dieterlin).

507. *B. alpinum* Huds. Transvaal, Haaskloof (Wager) as *B. Wilmsii* C. M.

512. *B. torquescens* Br. and Sch. Cape, W., Devil's Peak, Palmiet River and Keurbooms River (Dr. Barnard).

519. *B. Mundii* C. M. Basutoland, Leribe (Madame Dieterlin).

— *B. spinidens* Ren. and Card. (Trans. Roy. Soc. (S.A.), xviii, 3, p. 255, and figs. 12*a* and 12*b*. Natal, National Park (Wager). See Cordot, M. de Madagascar, page 303.)

522. *Rhodobryum Commersonii* Par. Cape, E., Hogsback (Miss Young); Insikeni (Henkel); Natal, Polela (Haygarth); Town Bush and Zwart Kop (Sim); Eshowe (v. d. Plank).

524. *Mnium rostratum* Schr. Cape, E., Stutterkeim Forest (Sister de Victoria); George (Miss Taylor); Basutoland, Qacha's Nek (K. Wilson).

527. *Aulacopilum trichophyllum* C. M. Cape, E., East London and Port St. John's (Wager); Natal, Port Shepstone (Sim).

528. *Erpodium Hanningtonii* Mitt. S. Rhodesia (Eyles 5204).

531. *Hedwigia albicans* Lindb. (should be 1–3 *inches* high). Cape, W. Stinkwater (Ex Rehm. 168); Basutoland, Qacha's Nek (K. Wilson); Natal. Many upland localities. It also occurs in Uganda and northward to Europe.

533. *Braunia secunda* Br. Eur. Many localities, including Western Province. Var. *longipila*, abundant in Rhodesia, also present in National Park, Natal (Wager).

534. *B. peristomata* Dixon. Evidently *Leucodon assimilis*.

535. *Rhacocarpus Ecklonianus* Broth. Cape, W., Hottentots' Holland Mountains (Miss Stephen); Genadendal (Stokoe); Kaapscheberg (Dr. Muir 3686).

537. *Wardia hygrometrica* Harv. Cape, W., North of Kleinpoort, Dewar's River, and at Smaaleblaar River, Worcester District (Fishery Survey).

538. *Fontinalis antipyretica* Linn. Cape, W., Eerste River (Fishery Survey); Hogelberg, near Gordon's Bay (Mogg).

542. *Leucodon assimilis* Jaeg. (includes *Braunia peristomata* Dixon). Cape, E., Wilderness (Mogg); Kentani (Miss Pegler); Cowie (Miss Bosman); S. Rhodesia, Zimbabwe (Miss Garubedian), (also Uganda, Dummer 987). Var. *denticulata* Dixon and Sim. Leaves distinctly toothed. Natal, Ngoya (Sim 10348).

543. *Forstroemia producta* Par. Transvaal, Pelindaba (Miss Bosman); O.F.S., Bloemfontein (Prof. Potts).

544. *Pterogonium ornithopodioides* Lindb. Natal, Fuller's Bush, Pietermaritzburg (Sim).

— *Hypnofabronia* (*Fabroniaceae*). Inner peristome absent, outer present.

— *H. marginata* Dixon ("New Genus and Species," Trans. Roy. Soc. (S.A.), xviii, 3, p. 258, and figs. 10, *a–d*). Leaf margin thickened, South African Goldfields, 1870 (T. Baines).

546. *Fabronia Gueinzii* C. M. Cape, E., Perie (T. R. Sim); Natal, Buccleuch (J. M. Sim); Greytown and Hilton Road (T. R. Sim); Eshowe (v. d. Plank 137).

547. *F. Rehmannii* C. M. Transvaal, Waterkloof Ravine and Zoutpansberg (Miss Bosman).

549. *F. pilifera.* Horns. Many additional localities in each area except Cape, W. It is also in Uganda.

552. *Ischyrodon seriolus* C. M. Transvaal, Rosehaugh (T. R. Sim).

553. *Dimerodontium africanum* C. M. Natal. Many localities. O.F.S., Harrismith (Dr. Potts).

554. *Schwetschkea Rehmannii* C. M. is *Helicodontium lanceolatum* Jaeg. (Dixon, Trans. Roy. Soc. (S.A.), xviii, 3, p. 258). East London (Wager).

556. *Pleuropus sericeus* Broth. Transvaal, Piet Retief (Haupt.); Rosehaugh (Sim); Basutoland, Qacha's Nek (K. Wilson). Var. *afro-striatus* C. M. Buccleuch (Sim 10321).

557. *Brachythecium implicatum* Jaeg.*

559. *B. salebrosum* Br. and Sch. Natal, Town Bush (Sim); Transvaal, Pretoria (Miss Bosman).

560. *B. pseudo-plumosum* Brid. (including *B. plumosum* B. and S.). Cape, E., Keurbooms River (Dr. Barnard); Transvaal, Pretoria (Miss Bosman). Basutoland, Qacha's Nek (K. Wilson).

561. *Oxyrrhinchium Macowanianum* Broth. Cape, E., Perie and Port St. John's (Wager).

562. *O. subasperum* Dixon. Cape, E., Grahamstown (Miss Britten).

— *Rhynchostegiella algeriana* Broth. "A slender form which is probably *R. pertinella* R. and C." Cape, E., Port St. John's (Wager); S. Rhodesia, Umtali (Wager). Dixon.

566. *R. Zeyheri* Spr.*

567. *Haplohymenium pseudo-triste* Br. Natal, Overwood, Polela and Gordon Falls, Edendale (T. R. Sim).

568. *Herpetineuron Toccoae* Card. Natal, Zwart Kop and Dargle Road (Sim).

570. *Lindbergia haplocladioides* Dixon. Cape, E., Grahamstown (Wager).

571. *L. patentifolia* Dixon. Abundant in all upper areas.

— *Pseudoleskea*; all S.A. species are now *Pseudoleskeopsis*, depending on the full development of the cilia (Thériot, Annales de Cryptogamie exotique, ii, 1).

574. *Pseudoleskeopsis claviramea* (C. M.) Thér.

575. *P. Macowaniana* (C. M.) Thér.

— *P. pseudo-attenuata* (C. M.) var. *perfecta* Dixon (described and illustrated Trans. Roy. Soc. (S.A.), xviii, 3, p. 259, and fig. 3).

577. *Haplocladium augustifolium* Broth.*

580. *Thuidium torrentium* C. M.* Except Rhodesia.

581. *T. versicolor* W. P. Sch.* And N. Rhodesia, Zambesi above Katomlares, 1925 (Miss Pocock).

— On page 388 illustration should be *Thuidium promontorii*.

— *Jaegerina stolonifera* C. M. (*Pterobryaceae*) is reported sterile (Trans. Roy. Soc. (S.A.), xviii, 3, p. 256, and pl. iii, figs. 8, *a*, *b*, *c*) from Port St. John's (Wager 1102). It is like *Calyptothecium Brotheri*, but has long longitudinally plicate leaves and shorter upper cells, with walls equally thickened all round. It was also collected elsewhere, and by Burtt-Davy in Nyasaland.

587. *Squamidium Rehmanni* Broth. Transvaal, Rustenburg (Prof. Moss); Rosehaugh (T. R. Sim); Pietersburg (Moss and Rogers 851).

588. *Papillaria africana* Jaeg. Calyptra densely pilose.

589. *P. natalensis* Sim. Transvaal, Rosehaugh (Sim 7428).

591. *Aerobryopsis capensis* Fliesch.*

592. *Pilotrichella panduraefolia* Jaeg. Many additional localities in Cape, E., and Natal. Transvaal, Entabeni (P. Watson 1578); Rosehaugh (T. R. Sim).

593. *P. chrysoneura* Jaeg. Cape, E., Kentani (Miss Pegler); Natal, Fuller's Bush, P. M. Burg (Sim).

595. *Leptodon Smithii* Mohr. Rhodesia, Mazoe (James Sim).

596. *Calyptothecium Brotheri* Dixon. Add, " Leaves when dry transversely undulated and rugose; apical cells shortly rhomboid; walls incrassate and porose.

597. *C. acutifolium* Broth. Natal, Zwart Kop (Sim).

Genus *Pinnatella*. Leaves small, roundish, with one small papilla on the lumen of each.

— *P. Engleri* Broth. Lundys Hill, Umkomaas (Sim 10333).

600. *Porothamnium natalense* Lindb. Dixon, who retains the name *Thamnium pennaeforme* (C. M.) var. *brachyphyllum* C. M. for the very slender small-leaved forms, puts all others in *T. pennaeforme* Lindb. I consider even that variety hardly worth a name, but easily see the difference between the extremes, bridged over by intergrading forms.

603. *Trachyphyllum gastrodes* Welw. and Duby. S. Rhodesia, Ironmask Hill, Mazoe (J. M. Sim).

604. *Levierella fabronacea* var. *abyssinica* Dixon. Natal, Zwart Kop and Gordon Falls, Edendale (T. R. Sim); National Park (Wager 698).

608. *Stereophyllum odontocalyx* Jaeg. Natal, Mont aux Sources (Dr. Doidge), serrulate.

613. *Entodon cymbifolius* W. and D. Transvaal, Pelindaba (Miss Bosman); Basutoland, Qacha's Nek (K. Wilson).

614. *E. brevirameus* Dixon. Transvaal; Pelindaba (Miss Bosman).

615. *Hygroamblystegium caudicale* Broth. Natal, Deepdale (Sim 10340). A delicate aquatic form. Tugela Gorge (Sim 8347).

617. *Amblystegium riparium* B. and S.* Also Kenya.

619. *Drepanocladus sparsus* C. M. A pathological form. Scheeper's Nek, Natal (Sim 8198).

623. *Microthamnium patens* Jaeg. Natal, Ngoya and Fuller's Bush, P. M. Burg. (Sim 10345); van Reenen (Wager); Transvaal, Pilgrims Rest (MacLea).

627. *M. cygnicollum* C. M. (=Eur. Shawii Rehm. 367). Cape, E., Perie (Sim); Natal, Eshowe (v. d. Plank).

628. *M. ctenidoides* Dixon. Cape, E., Umtentu River. Pondoland (J. Burtt-Davy).

Genus *Heterophyllium* replaces *Acanthocladiella*, and begins "Phyllogenes, buds and protenema all present." After end of page 423 add: The genus is moved again by P. de la Varde and M. Thériot into *Semato phyllaceae* (in Revue Bryologique, iii, 1–2, with pl. ii) along with the above species (except that *A. congoana* is sunk in *H. guineense* Broth. and is still *Heterophyllum*.

632. *Heterophyllium transvaaliensis* Thér and P. de la Varde. Paraphyllia almost absent; protenema present, and bearing buds sparingly. Cape, E., Umtentu River (J. Burtt-Davy).

633. *Acanthocladium trichocolea* Broth. Basutoland, Qacha's Nek (K. Wilson).

634. *Ectropothecium regulare* Jaeg. Cape, E., Keurbooms River, Knysna (Dr. Barnard 49188). Var. *complanatum* Dixon and Sim. Tufts dense, branches and leaves very complanate, the latter short, slightly falcate only, often obtuse. Town Bush Stream, Maritzburg (Sim 10343); Natal, Polela (Sim 10342).

638. *Isopterygium leucophanes* Jaeg.*

641. *I. strangulatum* Broth. Cape, E., Uitenhage (T. R. Sim); Umtentu River (J. Burtt-Davy).

642. *I. punctulatum* Broth. and W. Cape, W., Bain's Kloof (Primos);

Cape, E., Kentani (Miss Pegler); Natal, Eshowe (v. d. Plank); O.F.S., Wolhuter's Kop (Wager).

645. *Plagiothecium rhynchostegioides* C. M.*

646. *P. Hendersonii* Dixon. Cape, E., Perie (James Leighton); Natal, Winter's Kloof (T. R. Sim); Basutoland, Morija (Dr. Stoneman).

648. *Catagonium mucronatum* Broth. Cape, W., Garcia's Pass and Hermanus Hoek, Riversdale (Dr. Muir); Palmiet River Mountains (Dr. Barnard); Table Mountain (Mrs. Bolus); Cape, E., Keurbooms River, Knysna (Dr. Barnard).

649. *Vesicularia sphaerocarpa* Broth. Cape, W., Riversdale (Dr. Muir 3780); Natal, Buccleuch (W. Leighton); Town Bush (Sim); Eshowe (v. d. Plank).

651. *Sematophyllum Wageri* Wright=*Rhaphidostegium Wageri* (W. and W.) (Trans. Roy. Soc. (S.A.), xviii, 3, p. 260). Natal, National Park and Bergville (Wager). Transvaal, Pretoria (Wager); Port. E. Africa, Mozakwen Forest (Junod).

653. *S. sphaeropyxis* Broth.=*Rhaphidostegium sphaeropyxis* Jaeg.* Except Rhodesia.

654. *S. caespitosum* Mitt. var. *procerum* Rehm. Natal, Eshowe (v. d. Plank); Ngoya (Sim); Cape, E., Keurbooms River (Dr. Barnard).

655. *Rhaphidorrhynchium zuluense* Sim.

657. *Rhaphidorrhynchium Gueinzii* Broth. An aquatic form occurs at Palmiet River, Caledon (S.A.M.H. 41677).

659. *Distichophyllum Taylori* Sim. Seta one-third inch long; capsule small, sub-apophysate; the cells of its body round and very translucent, those of the neck and seta much longer but not wider. Peristome teeth narrow; processes rather longer. Perichaetal leaves like others but smaller. Cape, E., Knysna (fertile), July 1915 (Miss Duthie) (Herb., T. R. Sim).

661. *Eriopus mniaceus* Broth. Cape, W., Oudtshoorn District (Miss Taylor); Goedehope Farm, Hiedelberg (C. Thorne, S.A.M.H. 44494).

663. *Cyclodictyon vallis-gratiae* Broth. Cape, E., Port St. John's (Wager); Natal, Dargle Road and Ngoya (Sim); Eshowe (v. d. Plank).

664. *Hookeriopsis Pappeana* Jaeg. Cape, E., Port St. John's (Wager); Natal, Upper Tugela Valley (Dr. Doidge, Nat. Herb. 723B).

666. *Callicostella applanata* B. and B. Natal, Port Shepstone (Sim); Signal Hill, Eshowe (v. d. Plank) (pl. i, fig. 5).

667. *Hypopterygium laricinum* Brid. Frequent in each area.

668. *H. pennaeforme* Horns. Natal, Town Bush (Sim 7621).

670. *Rhacopilum capense* C. M. N. Rhodesia, above Katamlores (Miss Pocock); also Nairobi (sterile), and Uganda.

NOTE ON A SPECIAL HERMITIAN DETERMINANT.

By Sir Thomas Muir, F.R.S.

1. The determinant in question is

$$\begin{vmatrix} . & b_2+\beta_2 i & b_3+\beta_3 i & b_4+\beta_4 i \\ b_2-\beta_2 i & . & c_3+\gamma_3 i & c_4+\gamma_4 i \\ b_3-\beta_3 i & c_3-\gamma_3 i & . & d_4+\delta_4 i \\ b_4-\beta_4 i & c_4-\gamma_4 i & d_4-\delta_4 i & . \end{vmatrix}, \text{ or H say :}$$

and is seen to be fully specified as a zero-axial Hermitant of the 4th order. The interest attaching to it is due to the fact that there is inherent in its constitution a certain twinness or duality of form which is not apparent on the face of it, it being representable as the sum of two exactly similar expressions of the type

$$(x^2+y^2+z^2-2yz-2zx-2xy)+(u-v+w)^2+2\begin{vmatrix} x & u & 1 \\ y & -v & 1 \\ z & w & 1 \end{vmatrix}.$$

To attain precision we may say that in the one expression

$$x,\ y,\ z = b_2d_4,\ b_3c_4,\ b_4c_3 \quad \text{and} \quad u,\ v,\ w = \beta_2\delta_4,\ \beta_3\gamma_4,\ \beta_4\gamma_3,$$

and in the other

$$x,\ y,\ z = \beta_2d_4,\ \beta_3c_4,\ \beta_4c_3 \quad \text{and} \quad u,\ v,\ w = b_2\delta_4,\ b_3\gamma_4,\ b_4\gamma_3.$$

In other words, if we denote the typical expression by $\mathrm{F}\begin{pmatrix} x, & y, & z \\ u, & v, & w \end{pmatrix}$, then

$$\mathrm{H} = \mathrm{F}\begin{pmatrix} b_2d_4, & b_3c_4, & b_4c_3 \\ \beta_2\delta_4, & -\beta_3\gamma_4, & \beta_4\gamma_3 \end{pmatrix} + \mathrm{F}\begin{pmatrix} \beta_2d_4, & \beta_3c_4, & \beta_4c_3 \\ b_2\delta_4, & -b_3\gamma_4, & b_4\gamma_3 \end{pmatrix}.$$

2. To establish this we recall for use the general expansion of a Hermitant first obtained in 1897 and now spoken of as the "mixed" expansion because three different notational forms appear in it—the determinantal, the pfaffian, and the bipartite. As applied here it gives us for the determinant portion

$$\begin{vmatrix} . & b_2 & b_3 & b_4 \\ b_2 & . & c_3 & c_4 \\ b_3 & c_3 & . & d_4 \\ b_4 & c_4 & d_4 & . \end{vmatrix}$$

this being obtainable from H by deleting the second half of each binomial element.

For the second part it gives us

$$\begin{vmatrix} . & \beta_2 & \beta_3 & \beta_4 \\ -\beta_2 & . & \gamma_3 & \gamma_4 \\ -\beta_3 & -\gamma_3 & . & \delta_4 \\ -\beta_4 & -\gamma_4 & -\delta_4 & . \end{vmatrix} \quad \text{or} \quad \begin{vmatrix} \beta_2 & \beta_3 & \beta_4 \\ & \gamma_3 & \gamma_4 \\ & & \delta_4 \end{vmatrix}^2$$

this being obtainable from H by retaining only the Greek letters; and for the third part, the bipartite, it gives us

$$-\begin{array}{cccccc|c} \delta_4 & -\gamma_4 & \gamma_3 & \beta_4 & \beta_3 & \beta_2 & \\ \hline -b_2^2 & -b_2b_3 & -b_2b_4 & b_2c_3 & b_2c_4 & b_3c_4-b_4c_3 & \delta_4 \\ -b_2b_3 & -b_3^2 & -b_3b_4 & -b_3c_3 & b_2d_4-b_4c_3 & b_3d_4 & -\gamma_4 \\ -b_2b_4 & -b_3b_4 & -b_4^2 & b_2d_4-b_3c_4 & -b_4c_4 & -b_4d_4 & \gamma_3 \\ b_2c_3 & -b_3c_3 & b_2d_4-b_3c_4 & -c_3^2 & -c_3c_4 & c_3d_4 & \beta_4 \\ b_2c_4 & b_2d_4-b_4c_3 & -b_4c_4 & -c_3c_4 & -c_4^2 & -c_4d_4 & -\beta_3 \\ b_3c_4-b_4c_3 & b_3d_4 & -b_4d_4 & c_3d_4 & -c_4d_4 & -d_4^2 & \beta_2 \end{array}$$

of which the square array is identical with the array of the second compound of the determinant forming the first part and the border is a special arrangement of the elements of the pfaffian forming the second part.

Now the first of these three parts, as is well known, has for its final development

$$(b_2d_4)^2+(b_3c_4)^2+(b_4c_3)^2-2(b_2d_4)(b_3c_4)-2(b_3c_4)(b_4c_3)-2(b_4c_3)(b_2d_4):$$

the second equals

$$(\beta_2\delta_4-\beta_3\gamma_4+\beta_4\gamma_3)^2:$$

and the third, as vertical and horizontal bisection of it helps us to see, equals

$$-\begin{array}{ccc|c} \delta_4 & -\gamma_4 & \gamma_3 & \\ \hline -b_2^2 & -b_2b_3 & -b_2b_4 & \delta_4 \\ -b_2b_3 & -b_3^2 & -b_3b_4 & -\gamma_4 \\ -b_2b_4 & -b_3b_4 & -b_4^2 & \gamma_3 \end{array} - \begin{array}{ccc|c} \beta_4 & -\beta_3 & \beta_2 & \\ \hline -c_3^2 & -c_3c_4 & c_3d_4 & \beta_4 \\ -c_3c_4 & -c_4^2 & -c_4d_4 & -\beta_3 \\ c_3d_4 & -c_4d_4 & -d_4^2 & \beta_2 \end{array} - 2 \begin{array}{ccc|c} \delta_4 & -\gamma_4 & \gamma_3 & \\ \hline b_2c_3 & -b_3c_3 & b_2d_4-b_3c_4 & \beta_4 \\ b_2c_4 & b_2d_4-b_4c_3 & -b_4c_4 & -\beta_3 \\ b_3c_4-b_4c_3 & b_3d_4 & -b_4d_4 & \beta_2 \end{array}$$

$$\text{which} = \begin{array}{ccc|c} b_2\delta_4 & -b_3\gamma_4 & b_4\gamma_3 & \\ \hline 1 & 1 & 1 & b_2\delta_4 \\ 1 & 1 & 1 & -b_3\gamma_4 \\ 1 & 1 & 1 & b_4\gamma_3 \end{array} + \begin{array}{ccc|c} \beta_4c_3 & -\beta_3c_4 & \beta_2d_4 & \\ \hline 1 & 1 & -1 & \beta_4c_3 \\ 1 & 1 & 1 & -\beta_3c_4 \\ -1 & 1 & 1 & \beta_2d_4 \end{array}$$

$$-2\begin{vmatrix} \delta_4 & -\gamma_4 & \gamma_3 \\ b_2c_3 & -b_3c_3 & . \\ b_2c_4 & . & -b_4c_4 \\ . & b_3d_4 & -b_4d_4 \end{vmatrix}\begin{matrix}\beta_4\\ -\beta_3\\ \beta_2\end{matrix} \quad -2\begin{vmatrix} \delta_4 & -\gamma_4 & \gamma_2 \\ . & . & b_2d_4-b_3c_4 \\ . & b_2d_4-b_4c_3 & . \\ b_3c_4-b_4c_3 & . & . \end{vmatrix}\begin{matrix}\beta_4\\ -\beta_3\\ \beta_2\end{matrix}$$

$$= +\{(b_2\delta_4)^2+(b_3\gamma_4)^2+(b_4\gamma_3)^2-2(b_2\delta_4)(b_3\gamma_4)+2(b_2\delta_4)(b_4\gamma_3)-2(b_3\gamma_4)(b_4\gamma_3)\}$$
$$+\{(\beta_4c_3)^2+(\beta_3c_4)^2+(\beta_2d_4)^2-2(\beta_4c_3)(\beta_3c_4)-2(\beta_4c_3)(\beta_2d_4)-2(\beta_3c_4)(\beta_2d_4)\}$$

$$+2\begin{vmatrix} \beta_2d_4 & b_2\delta_4 & 1 \\ \beta_3c_4 & -b_3\gamma_4 & 1 \\ \beta_4c_3 & b_4\gamma_3 & 1 \end{vmatrix} \quad +2\begin{vmatrix} b_2d_4 & \beta_2\delta_4 & 1 \\ b_3c_4 & -\beta_3\gamma_4 & 1 \\ b_4c_3 & \beta_4\gamma_3 & 1 \end{vmatrix}.$$

The three parts of the mixed expansion of H are thus shown to be equal to the sum of six (1 + 1 + 4) expressions, the first, second, and sixth of which constitute

$$\mathrm{F}\begin{pmatrix} b_2d_4, & b_3c_4, & b_4c_3 \\ \beta_2\delta_4, & -\beta_3\gamma_4, & \beta_4\gamma_3 \end{pmatrix},$$

and the third, fourth, and fifth constitute

$$\mathrm{F}\begin{pmatrix} \beta_2d_4, & \beta_3c_4, & \beta_4c_3 \\ b_2\delta_4, & -b_3\gamma_4, & b_4\gamma_3 \end{pmatrix}.$$

The property of §1 is thus established.

3. Although no better proof is known than that just shown to depend on the " mixed " expansion, a partial verification of an interesting character has recently become possible through the discovery * that every Hermitant is expressible as a Pfaffian with the elements free of $\sqrt{-1}$; that, for example, our H is identical with

$$\begin{vmatrix} \beta_2 & \beta_3 & \beta_4 & b_4 & b_3 & b_2 & . \\ & \gamma_3 & \gamma_4 & c_4 & c_3 & . & b_2 \\ & & \delta_4 & d_4 & . & c_3 & b_3 \\ & & & . & d_4 & c_4 & d_4 \\ & & & & -\delta_4 & -\gamma_4 & -\beta_4 \\ & & & & & -\gamma_3 & -\beta_3 \\ & & & & & & -\beta_2 \end{vmatrix}, \text{ or } \Phi \text{ say.}$$

Well-known properties of Pfaffians tell us at once that a portion of the development of Φ is

$$\begin{vmatrix} b_4 & b_3 & b_2 & . \\ c_4 & c_3 & . & b_2 \\ d_4 & . & c_3 & b_3 \\ . & d_4 & c_4 & b_4 \end{vmatrix}$$

* *Edinb. Math. Soc.*, Note 26, pp. v.–ix.

and that another portion is

$$\begin{vmatrix} \beta_2 & \beta_3 & \beta_4 \\ & \gamma_3 & \gamma_4 \\ & & \delta_4 \end{vmatrix} \cdot \begin{vmatrix} -\delta_4 & -\gamma_4 & -\beta_4 \\ & -\gamma_3 & -\beta_3 \\ & & -\beta_2 \end{vmatrix} \text{ or } \begin{vmatrix} \beta_2 & \beta_3 & \beta_4 \\ & \gamma_3 & \gamma_4 \\ & & \delta_4 \end{vmatrix}^2$$

as being a product of complementary minors. Further, by interchanging the 4th and 5th frame-lines and then multiplying the new 5th frame-line by -1 we obtain as an equivalent of Φ

$$\begin{vmatrix} \beta_2 & \beta_3 & b_4 & -\beta_4 & b_3 & b_2 & . \\ & \gamma_3 & c_4 & -\gamma_4 & c_3 & . & b_2 \\ & & d_4 & -\delta_4 & . & c_3 & b_3 \\ & & & . & -\delta_4 & -\gamma_4 & -\beta_4 \\ & & & & -d_4 & -c_4 & -b_4 \\ & & & & & -\gamma_3 & -\beta_3 \\ & & & & & & -\beta_2 \end{vmatrix},$$

and thus learn similarly that

$$\begin{vmatrix} \beta_4 & b_3 & b_2 & . \\ \gamma_4 & c_3 & . & b_2 \\ \delta_4 & . & c_3 & b_3 \\ . & \delta_4 & \gamma_4 & \beta_4 \end{vmatrix} \text{ and } \begin{vmatrix} \beta_2 & \beta_3 & b_4 \\ & \gamma_3 & c_4 \\ & & d_4 \end{vmatrix}^2$$

are other two portions of the development. If now we could only show as easily that

$$2\begin{vmatrix} b_2d_4 & \beta_2\delta_4 & 1 \\ b_3c_4 & -\beta_3\gamma_4 & 1 \\ b_4c_3 & \beta_4\gamma_3 & 1 \end{vmatrix} \text{ and } 2\begin{vmatrix} \beta_2d_4 & b_2\delta_4 & 1 \\ \beta_3c_4 & -b_3\gamma_4 & 1 \\ \beta_4c_3 & b_4\gamma_3 & 1 \end{vmatrix}$$

are the remaining portions, we should indeed be fortunate.

4. In the course of a fruitless attempt to provide this missing link I incidentally came across the fact that the second F of §1 has a variant, namely,

$$\mathrm{F}\begin{pmatrix} \beta_2d_4, & b_3\gamma_4, & b_4\gamma_3 \\ b_2\delta_4, & -\beta_3c_4, & \beta_4c_3 \end{pmatrix};$$

and then reasoning by analogy I obtained a variant for the first F also, namely,

$$\mathrm{F}\begin{pmatrix} b_2d_4, & \beta_3\gamma_4, & \beta_4\gamma_3 \\ \beta_2\delta_4, & -b_3c_4, & b_4c_3 \end{pmatrix}.$$

As a consequence it was soon found that *the typical expression of* §1

$$i.e.\ \mathrm{F}\begin{pmatrix} x, & y, & z \\ u, & -v, & w \end{pmatrix}$$

is not altered by interchanging y *with* v *and* z *with* w—a fact that follows at once from showing that it can be readily transformed into

$$x^2+y^2+z^2+u^2+v^2+w^2-2(x+w)(y+v)-2(x-u)(z+w)-2(y-v)(z-w).$$

5. In conclusion it may be well to make a note of two results, not altogether relevant, which were come across during the investigation of the subject proper.

The first is that *the product of the twin Pfaffians of a Hermitant is expressible as the sum of two squares.* Thus, taking our H as an example, we have

$$\begin{vmatrix} b_2+\beta_2 i & b_3+\beta_3 i & b_4+\beta_4 i \\ c_3+\gamma_3 i & c_4+\gamma_4 i & \\ d_4+\delta_4 i & & \end{vmatrix} = \begin{vmatrix} b_2 & b_3 & b_4 \\ c_3 & c_4 & \\ d_4 & & \end{vmatrix} - \begin{vmatrix} \beta_2 & \beta_3 & \beta_4 \\ \gamma_3 & \gamma_4 & \\ \delta_4 & & \end{vmatrix} + \begin{vmatrix} b_2 & b_3 & \beta_4 \\ c_3 & \gamma_4 & \\ \delta_4 & & \end{vmatrix} i + \begin{vmatrix} \beta_2 & \beta_3 & \beta_4 \\ \gamma_3 & c_4 & \\ d_4 & & \end{vmatrix} i,$$

$$= f_1 - f_2 + (f_3+f_4)i, \text{ say}$$

and, by altering the signs of the Greek letters,

$$\begin{vmatrix} b_2-\beta_2 i & b_3-\beta_3 i & b_4-\beta_4 i \\ c_3-\gamma_3 i & c_4-\gamma_4 i & \\ & d_4-\delta_4 i & \end{vmatrix} = f_1 - f_2 - (f_3+f_4)i$$

so that the product of the two Pfaffians is

$$(f_1-f_2)^2+(f_3+f_4)^2.$$

6. The other result concerns determinants in general, and is more curious than useful; any interest claimed by it is due to its relationship to Cayley's expansion of 1847 in terms of zero-axial minors. For the 4th order it is

$$|\, a_1 b_2 c_3 d_4 \,| = a_1 b_2 c_3 |\, d_4 \,| + a_1 b_2 |\, c_3 d_4 |_{c_3=0} + a_1 |\, b_2 c_3 d_4 |_{b_2=0} + |\, a_1 b_2 c_3 d_4 |_{a_1=0}$$

In a footnote to p. 54 of *Hist.*, III, will be found another relative.

RONDEBOSCH, S. AFRICA,
14*th August* 1930.

ON THE HERPETOLOGICAL FAUNA OF THE LOBATSI-LINOKANA AREA.

By J. H. Power.

(With Appendix and two Text-figures.)

Part II.—Linokana, 25° 27′ S., 25° 52′ E.

Introduction.

The present paper is a continuation of that published in 1927 (**1**), and is a record of field studies made at Linokana during January 1928 and January 1930. It deals with all the herpetological material collected during the two expeditions.

The main objects of these field excursions were to throw some light, if possible, on the identity of the toad known as *Bufo tuberculosus*, Bocage, and to work out the relationship between the reptile and amphibian fauna of Lobatsi and Linokana.

The native village of Linokana is situated in a valley, running N.W. and S.E., between the range of hills which bears its name and the Moilos Range. The former consists entirely of dolomite and banded ironstone, while the latter is composed of quartzite. The country to the south and west, immediately beyond the Linokana Hills, consists of sandy flats covered with grass and scrub; to the north there is range after range of hills, more or less parallel and running N.W. and S.E., with fertile valleys between. The S.W. slopes of these ranges are comparatively steep and grassy, with scattered trees, while the N.E. slopes are very gradual and are thickly wooded. A good stream of clear, fresh water, which flows from the dolomite on the south side of the valley and behind the village, is flanked by many fine indigenous trees. At the foot of these trees are quantities of maiden-hair fern, giving those spots, where the sunlight filters through the trees, a tinge of rare beauty.

The whole native reserve, including Gopani and Mochudi, is 21,000 square miles.

This area offered almost virgin terrain, for only one other naturalist had previously visited Linokana, Dr. Emil Holub (**2**).

I was rather unlucky in the matter of rain, for in all three trips only on one occasion did it fall during my stay.

One of the most unexpected results of my collecting here was the discovery, in many cases, of different species of a genus from those found at Lobatsi. The reptile and amphibian fauna of the two localities is about equal as far as number of species is concerned, but the difference in species is remarkable. The localities are similar in climate, vegetation, and topography, a fact which makes this difference all the more surprising.

A comparison of the list of species from both places, on p. 48, shows at a glance this herpetological differentiation.

In some cases the differences between the Lobatsi and Linokana reptile and amphibian fauna may be due to habitat conditions. The absence of *Rana delalandi* from Lobatsi may be due to the fact that it apparently requires a perpetual water-supply, which does not exist there, the pools and streams being dried up in dry seasons. This desiccation, *Rana oxyrhynchus* seems to be able to withstand.

The country immediately to the north and west of this area certainly offers a most interesting field for further herpetological exploration.

In view of the fact that I have paid only two short visits to Linokana, it is not possible to present a complete list of the reptiles and amphibians of that section, but the material collected is very valuable from a distributional point of view. In all, 800 specimens were collected, as follows: 276 frogs, 300 toads, 160 lizards, 40 snakes, and 17 tortoises. The major portion of these has been lodged in the M'Gregor Museum, Kimberley, while others have been distributed among the other museums and scientific institutions of the country.

The preceding papers do not pretend to give an exhaustive account of the herpetological fauna of Lobatsi or Linokana, at most they are but a contribution to the study of this most interesting area.

My thanks are due to the Research Grant Board, without whose assistance this work could not have been accomplished. I have much pleasure also in acknowledging my indebtedness to Mr. and Mrs. E. C. Gallichan, whose guest I was during my two visits to Linokana.

Annotated List of Species.

Lacertilia.

Lygodactylus capensis, Smith.

This is undoubtedly the commonest Gecko in S. Africa to the north of the Orange River. It seems to abound everywhere throughout the country, and is frequently found on the garden-fences of houses which are situated

in the centre of towns. It is common on the Acacia trees which grow among the native huts at Linokana. The colour varies but little even in specimens from places widely separated; those taken at the above locality were coloured exactly similar to specimens found at Kimberley.

Pachydactylus capensis, Smith.

This species is not common at Linokana. One specimen only was taken, under a stone.

Agama atra atra, Daud.

Atra is found on the dolomite hills behind the village. In colour, specific characters, and habitat, it differs in no particular from specimens taken in the Cape Peninsula.

Agama atricollis, Smith.

This species is plentiful, especially in the village, where it inhabits the tops of a group of high Acacia trees. This is significant in view of Schmidt's (3) assertion that "this species in the greater part of its habitat depends on and shifts with human settlements." Its liveliness and protective colouration are its principal protection. One large female taken on 12th January 1929 contained 8 eggs which averaged 19·2 mm. by 12·5 mm.

Several large specimens of this species were secured by shooting them from the tree-tops.

Agama hispida distanti, Boul.

Distanti may be found in the valleys between the hills, where it lives in holes or under stones. It is interesting to note that the three species of Agama found in the Lobatsi-Linokana area occupied separate habitats. *Atra*, as usual, kept to the rocky hills, *distanti* preferred the flat valleys, where it might be seen on the top of a fence-post, while *atricollis* favoured the high Acacia trees.

Zonurus cordylus vittifer, Riech.

This form was found under stones, and in clefts between stones, on the slopes of the hills. *Zonurus cordylus jonesii*, apparently, does not occur here. This is rather remarkable, as the distance, by road, from Lobatsi to Linokana is only 23 miles, and there is no barrier, natural or artificial, separating the two places.

Veranus niloticus, Linn.

This common aquatic lizard is found in the rivers and streams, but, owing perhaps to being hunted by the natives for its skin, which is supposed to cure rheumatism, it is not so plentiful.

Nucras intertexta, Smith.

Common on the bare, sun-baked patches of ground in the valleys. It was not noticed in grassy situations. Both the Lobatsi and Linokana specimens belong to the var. *holubi*, and in colouration agree with fig. 3, Pl. VII, in Boulenger's paper (**4**).

Gerrhosaurus flavigularis, Wiegm.

This lizard is common at Linokana. It is not confined to any particular habitat, being found on the tops of the hills and in the valleys. The long tail of this lizard is quite flexible, but at the slightest pull it breaks off and the lizard makes its escape apparently unhurt.

Unlike those taken at Lobatsi, the Linokana specimens have no suture between the praefrontals. Further, to my remarks on *nigrolineatus*, in the first part of this work, it may be added that some years ago this species was reduced to a variety of *flavigularis* by Tornier (**5**), and his view was endorsed by Werner and Roux, but Dr. Boulenger retained it. I have re-examined the specimen from Lobatsi, and find that as regards the praefrontal character it certainly agrees with Hallow's *nigrolineatus*.

Schmidt (**6**), writing of *flavigularis* and *nigrolineatus*, says, "the area in which the two forms intergrade is very large, and in addition there are probably sporadic specimens of *flavigularis flavigularis* which appear to be *nigrolineatus*." With considerable hesitation he suggests that all South and East African specimens should be referred to *flavigularis, sensu strictu*, while the West African and South-West African specimens should be referred to *nigrolineatus*. In view of this the material from Lobatsi and Linokana, in the centre of South Africa, are particularly interesting.

Mabuia varia, Pet.

A common lizard among the rocks on the hills. It is said by Hewitt (**7**) to closely resemble *M. striata*. Possibly some young specimens of *varia* might be confused with juveniles of *striata*, but the adults are very distinct. The author has never found any difficulty in distinguishing this species from *striata* on the colour characters alone. In addition the difference in size of the adults is considerable. Twenty adult specimens of each, taken at random, gave the following average length, measured from snout to vent: *varia*, 58 mm.; *striata*, 84 mm.

Mabuia striata, Pet.

Mabuia striata inhabits the large Acacia trees. In colouration, those collected in the neighbourhood under review do not differ from Kimberley specimens.

Mabuia trivittata, Cuv.

This form has the typical colouration of specimens from Griqualand West.

As in the case of the *Agamas* the three skinks have distinct habitats. *Varia* is confined to the rocks on the hills, *striata* prefers the tall Acacias, while *trivittata* is found under stones, among the undergrowth, or in holes in the ground.

Ophidia.

Python sebae, Gmel.

Only one juvenile specimen of this large snake was taken. Nevertheless the presence of a permanent water-supply and thickly wooded kloofs must make Linokana a desirable neighbourhood for them.

Ablabophus rufulus, Licht.

Several specimens were collected at night along the partially dried beds of streams, evidently searching for frogs.

Boodon lineatus, Dum. and Bibr.

This is a widely distributed species extending into Central Africa. The one specimen found was taken under a stone. It conformed to the usual colouration for this species.

Philothamnus semivariegatus, Smith.

Only one specimen of this snake was taken, but it may be quite plentiful. Unless it moves in the branches of the small trees, where it lies, it is almost impossible to see.

Psammophis sibilans, Linn.

One specimen was taken in the long grass near water. This is undoubtedly *sibilans*; it differs from the Lobatsi specimen in the number of upper labials entering the eye, as well as in colouration.

The Lobatsi specimen is brown above, the seven middle rows of scales a darker brown edged with black, and separated from the sides by distinct yellow lateral stripes, which converge on each other within about three inches of the head, from this point to the head are yellow transverse crossbars, a quarter of an inch apart and seven in number; head with yellow marblings edged with black, upper labials yellowish with black dots and a black line on their upper border; the ventral surface yellowish with a black line on either side running along near the outer edges of the ventrals.

The Linokana specimen has the seven middle rows of scales pale olive edged with black, a pale yellow vertibral streak reaching to within about four inches of the head ; the sides light grey ; head and front portion of the body uniform greyish-olive, upper labials yellowish mottled with olive ; ventral surface yellowish-white, with a faint grey stripe along either side of the belly.

Dispholidus typus, Smith.

A sloughed skin of this species was found in a low thorn tree, in long grass. It is evidently not very plentiful, for a close search of the wooded kloofs failed to reveal any further specimens.

Naia haje, Linn.

Five specimens were taken, and they all belong to the colour variety *annulifera*. This species is replaced by *nigricollis* at Lobatsi. Apparently the latter does not occur at Linokana.

Chelonia.

Testudo oculifera, Kuhl.

The finding of this tortoise at Linokana extends its northern distribution considerably. It is quite common on the grassy flats immediately to the south-west of the village and beyond the Linokana Hills, but is, apparently, entirely absent from the country to the north-east of these hills. Here is, evidently, a case where a range of hills forms a natural barrier to the spread of the species, for it is found on the one side and not on the other. This was the only tortoise noticed in the neighbourhood.

Batrachia.

Rana delalandi, Dum. and Bibr.

The occurrence of this species at Linokana and not at Lobatsi is remarkable. Both adults and larvae were found in numbers along all the permanent streams of water. There is, apparently, no reason why both *R. delalandi* and *R. oxyrhynchus* should not be found at both places, yet the one is found at Linokana and the other at Lobatsi.

Pyxicephalus natalensis, Smith.

Six males were taken, while calling at night, on the edge of a running stream. This record is one of particular interest, as it materially extends the previously known west central South African range of the species, and brings it close to the Bechuanaland border.

This form is smaller than *P. delalandi*, the snout is more pointed, and the inner metatarsal tubercle smaller. The specimens from Linokana give the following colour :—

Above, uniform grey or with slightly darker spots and marblings, with or without two small, light, black-edged spots, just behind the parietal region ; darker cross-bars on the arms and legs. Sides whitish, speckled with minute grey spots, lips yellowish, speckled with dark grey ; a dark patch extending from behind the tympanum, passing through the eye, just below the upper eyelid and through the nostril to the end of the snout ; whitish beneath, the chin and sides of the throat in breeding males very dark grey.

In his key (**8**) to the species of *Pyxicephalus*, Boulenger says of *natalensis* " tarso-metatarsal articulation nearly reaching the end of the snout." In the case of all six specimens from Linokana, the tarso-metatarsal articulation extends distinctly beyond the snout. The toes, measuring from the metatarsal tubercle, are somewhat less than half webbed.

The average length for the six males is 30·5 mm.

The call of the male is a high-pitched tut—tut—tut, continued for a time until something disturbs the creature.

Pyxicephalus delalandi, Tesch.

This widely distributed frog is plentiful during the evening and night following a rainstorm, at other times one seldom sees it.

Cassina senegalensis, Dum. and Bibr.

This frog was not seen, but the characteristic tadpoles were found in a pool of muddy rain-water.

Phrynomerus bifasciatus, Smith.

Two specimens were found calling at night, after rain, in a depression filled with water.

Cacosternum boettgeri, Boul.

This species is common at Linokana. The call is identical with that of males, heard by the author, at places as far apart as Mossel Bay, Kimberley, and Postmasburg. Evidently the colour, voice, and habits are uniform throughout the country.

Bufo regularis regularis, Reuss.

This common toad is fairly plentiful in the locality under review.

Boettger (**9**) recorded *B. angusticeps* from Linokana, but this is certainly

a mistake, for it does not occur there. He most probably got some immature specimens of *B. regularis gutturalis.*

Bufo regularis gutturalis, Power.

This form is quite common at Linokana.

I suspect very strongly that this is the same as *B. tuberculosus*, Bocage. As pointed out in Part I of this report, the specimens collected by me differ in many essential respects from Bocage's description. He may have had only one adult specimen at his disposal, and that possibly a desiccated one, in which case comparative measurements and colour would differ considerably.

I have taken this form at Linokana, Lobatsi, Kuruman, and Upington, in every case in conjunction with *B. regularis.*

Observations made at all the above places confirm the opinion that, while not deserving of specific rank, this is a good form. The males had the same guttural call, most unlike that of *regularis*, wherever they were heard.

Apparently *gutturalis* does not occur south of a line joining Linokana–Kuruman–Upington, for the author failed to discover it at Postmasburg, Witsands, Griquatown, Prieska, Marydale, Kenhardt, Kakamas.

What its distribution to the north may be still remains unknown. It occurs in Southern Rhodesia.

APPENDIX

The following are further notes and records for the Lobatsi section of this work :—

Lygodactylus capensis, Smith.

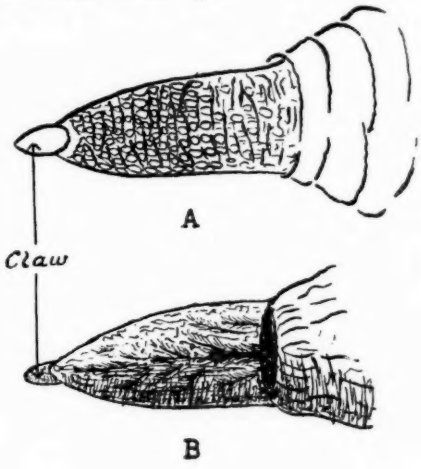
Three specimens of this species taken in 1928, in trees among the Lobatsi Hills, far from human habitations, were of a light grey colour dorsally. One of these had half the ventral surface of the tail armed with broad transverse plates ; the tail was not regenerated. In specimens collected by Loveridge (**10**) at Lombo, P.E.A., the under surface of the tail was similarly armed. He used this character to put the specimens into a subspecies which he named *mossambica.* Probably this character will be found to vary.

Cinixys lobatsiana, Power.

A further visit to Lobatsi in January 1928 resulted in the securing of a further 14 adult specimens of this interesting species ; they consisted of 9 males and 5 females. Some further particulars have been obtained by an examination of this additional material.

The tip of the tail in both sexes is armed with a prominent claw (see fig. 1), not unlike that on a fowl's toe, but, of course, much smaller. In the case of the male this claw is very much larger than in the female. In

all but one of the males the tail is directed to the left when in repose ; in all the females it is turned to the right.



A.– Dorsal view of tail.
B.– Ventral view of tail.

FIG. 1.

The 5 females contained partially developed embryos as follows : 2, 3, 4, 3, 2, so it would appear that the average number of eggs laid at a time

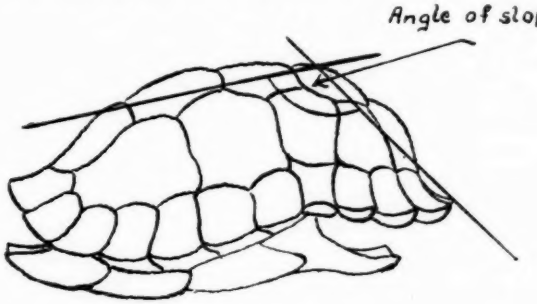


FIG. 2.

is about 3. The author considers that they would have been laid about the end of January.

The following table of measurements gives the averages in millimetres for 9 males and 5 females :—

Sex.	Total Length.	Total Breadth.	Angle of Slope of Posterior of Carapace.	Length of Tail.
Males . . .	156	101 *	123° †	38 ‡
Females . . .	154	100	114°	25

* The greatest width in the male is between the extremities of the hinge; that of the female is across the centre of the body.

† Lines taken from highest point of first neural to highest point of fourth and thence to tip of caudal (see fig. 2).

‡ The length of the tail is taken from the vent to the tip of the caudal claw.

Pelomedusa galeata, Schoep.

Since the Lobatsi section of this work was published, a couple of specimens of the water tortoise occurring there have been secured.

This species was not observed at Linokana.

The following comparative list of species for the two localities is of interest :—

Lacertilia.

Lobatsi.	Linokana.
Pachydactylus capensis.	*Pachydactylus capensis.*
Lygodactylus capensis.	*Lygodactylus capensis.*
Agama hispida distanti.	*Agama hispida distanti.*
,, *atra atra.*	,, *atra atra.*
,, *atricollis.*	,, *atricollis.*
Zonurus cordylus vettifer.	*Zonurus cordylus vettifer.*
,, *jonesii.*	No.
Varanus niloticus.	*Varanus niloticus.*
,, *albigularis.*	?
Nucras intertexta var. *holubi.*	*Nucras intertexta* var. *holubi.*
Ichnotropis squamulosa.	No.
Gerrhosaurus nigrolineatus.	*Gerrhosaurus flavigularis.*
Mabuia varia.	*Mabuia varia.*
,, *striata.*	,, *striata.*
,, *trivittata.*	,, *trivittata.*
Chameleon quilensis.	?

Ophidia.

Python sebae.	*Python sebae.*
Philothamnus semivariegatus.	*Philothamnus semivariegatus.*
Trimerorhinus tritaeniatus.	No.
Psammophis subtaeniatus.	*Psammophis sibilans.*
Thelotornis kirtlandi.	*Dispholidus typus.*
Naia nigricollis.	*Naia haja.*
No.	*Ablabophis rufulus.*
No.	*Boodon lineatus.*

Chelonia.

Cinixys labatsiana.	*Testudo oculifera.*
Pelomedusa galeata.	?

Amphibia.

Rana oxyrhynchus.	*Rana delalandii.*
Pyxicephalus delalandii.	*Pyxicephalus delalandii.*
,, *adspersus.*	?
No.	*Pyxicephalus natalensis.*
Phrynobatrachus natalensis.	No.
Cassina senegalensis.	*Cassina senegalensis.*
Cacosternum boettgeri.	*Cacosternum boettgeri.*
Phrynomerus bifasciatus.	*Phrynomerus bifasciatus.*
Bufo regularis regularis.	*Bufo regularis regularis.*
,, ,, *gutturalis.*	,, ,, *gutturalis.*
,, *carens.*	,, *carens.*
,, *vertebralis albiventer.*	No.
Xenopus laevis.	*Xenopus laevis.*

LITERATURE CITED.

(1) Power, J. H.—Trans. Roy. Soc. S. Afr., xiv, p. 405, 1927.
(2) Holub, E.—Seven Years in South Africa, pp. 416, 419.
(3) Schmidt, K. P.—Bull. Amer. Mus. Nat. Hist., xxxix, p. 468, 1919.
(4) Boulenger, G. A.—Ann. S. Afr. Mus., xiii, pls. vi–vii, 1913.
(5) Tornier, G.—Zool. Jahrb. (Syst.), xiii, p. 594, 1900.
(6) Schmidt, K. P.—Bull. Amer. Mus. Nat. Hist., xxxix, p. 524.
(7) Hewitt, J.—Ann. Trans. Mus., ii, p. 95.
(8) Boulenger, G. A.—Ann. S. Afr. Mus., v, p. 527, 1910.
(9) Boettger, O.—Ber. Seneck. Ges., 1887.
(10) Loveridge, A.—Proc. Zool. Soc. of Lond., p. 135, 1920.

AN ILLUSTRATED ANALYSIS OF PREHISTORIC ROCK-PAINTINGS FROM PELZER'S RUST.

By C. van Riet Lowe.

(With two Text-figures.)

1. Introduction.

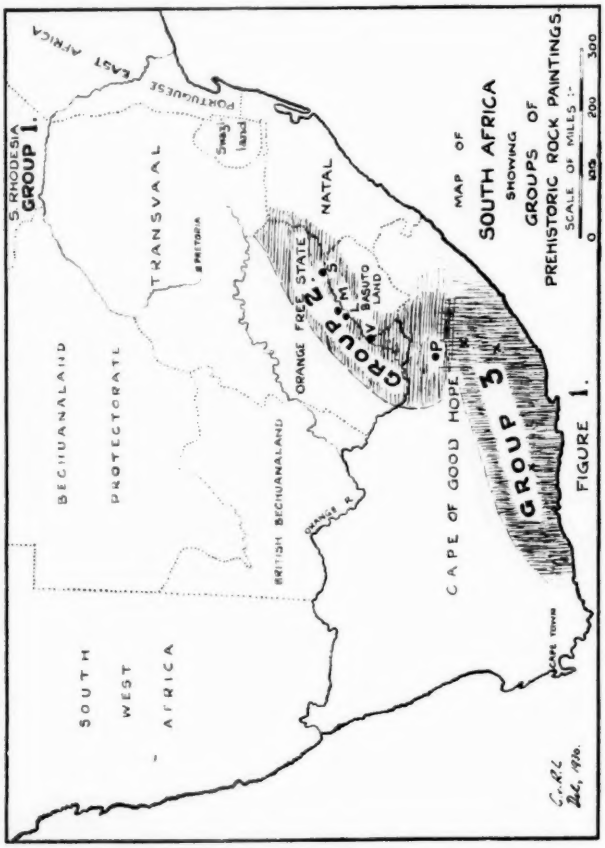
One of the most important aspects of the study of prehistoric rock-paintings centres on the sequence of colours and styles as revealed to us by superposition. It is also one of the most difficult, and any investigation to be of real scientific value must be completely and carefully carried out.

Largely on the assumption that all rock-paintings in South Africa were the work of not very ancient Bushmen, early workers in the field missed making many vital observations, and their great works have therefore reached us in a condition that does not help the scientific study of the subject as it needs to be helped. While their work is of inestimable value as a pictorial or artistic record, it unfortunately can rarely be used in any attempt to solve such problems as confront us. One does not, of course, attach any blame to those early workers; it is just unfortunate that the subject was at that time not so fully understood and appreciated as it is to-day.

In the absence of being able to do actual field-work, deductions from available works are frequently liable to be quite useless. It is, for example, often fatal to work on copies that do not represent all the work in a cave, and equally fatal to work on copies that are not exact. Sites should actually be visited, and the paintings in them studied as a whole. All superpositions and styles should be noted. It is, for example, possible in a single cave to find certain superpositions in one part and the reverse, or apparently the reverse, in another, and a visitor—particularly an artist—picking out the most striking groups or portions of groups, might copy one and not the other. This has invariably happened in the past and, from a purely archaeological point of view, is most indicative of the need for the application of archaeological method by properly trained scientists.

The wonderful works of Miss Helen Tongue (1), of Stow (2), and of Maack (3) are outstanding for merit and faithful reproduction, but they do

not help the proper study of prehistory as it needs to be helped. Our gratitude for the superb manner in which they have presented to us so many existing works is unbounded; our admiration for the way in which



they have preserved for posterity many paintings that have been destroyed and many that are now rapidly disappearing is equally great, but their works, valuable as they are, can, from a purely archaeological point of view, only be termed impressionistic (4), and, in the light of present knowledge, it behoves us now to take every advantage we possibly can of opportunities scientifically to study the subject.

To those who have been fortunate enough to do actual field-work, as

to all students of experience, it is known that a long study of superpositions does reveal certain general sequences of both colours and styles in given areas, and it is only by experience and patient and complete investigation that one is able ultimately to build up a working hypothesis that provides a basis for further fruitful investigation.

The earliest indication of any scientific attempt to study superpositions in South Africa was undertaken by Burkitt (5). He was the first to indicate certain colour sequences and regional distribution of colours and styles, and from his lead several workers have gone far afield.

When M. l'Abbé Breuil visited South Africa with the British Association for the Advancement of Science in 1929, it was my pleasure to take him to a number of rock-shelters and caves richly decorated with prehistoric paintings; and as a result of his observations in widely separated and typical caves in the eastern Orange Free State, he arrived at the sequence of colours and styles set out in the accompanying Table for Ventershoek (V on map), Ladybrand (L on map), Modderpoort (M on map), and Schaapplaats (marked S on map in fig. 1) (6). His visit was, unfortunately, somewhat hurried, but each cave was completely investigated, and his profound knowledge of prehistoric art is such that his observations are invaluable, and although, in this instance, entirely tentative, not without great significance. At least his work provides an instructive basis for future investigation in the area referred to, and is therefore a precious record (7).

During the following year (1930) I travelled extensively through the north-eastern districts of the Cape Province, and was able in the course of my journeys to visit and examine many caves once occupied by primitive man (8). It is therefore interesting to note that my observations in this area corroborate not only those of my earlier work in the Orange Free State, but also bear out the wider application and correctness of the Abbé's analyses.

2. Rock-paintings at Pelzer's Rust.

As an illuminating example of superpositions, I have selected, partially to illustrate and to record, a decorated rock-shelter on the farm Pelzer's Rust, in the Stormberg Valley near Burghersdorp, C.P. (marked " P " on the map shown in fig. 1). Here, in a modest fresco, we have two illuminating cases:

Case I (fig. 2).

Black (naturalistic but not too good)

over

Bichrome (Red & White) and Polychrome (Black, Brown, Grey & White)
(both best naturalistic)

over

Pale Yellow (naturalistic).

Case II.

Bichrome (Red & Yellow) (best naturalistic)
over
Red-Brown (naturalistic) and Red Strong (naturalistic)
over
White (naturalistic).

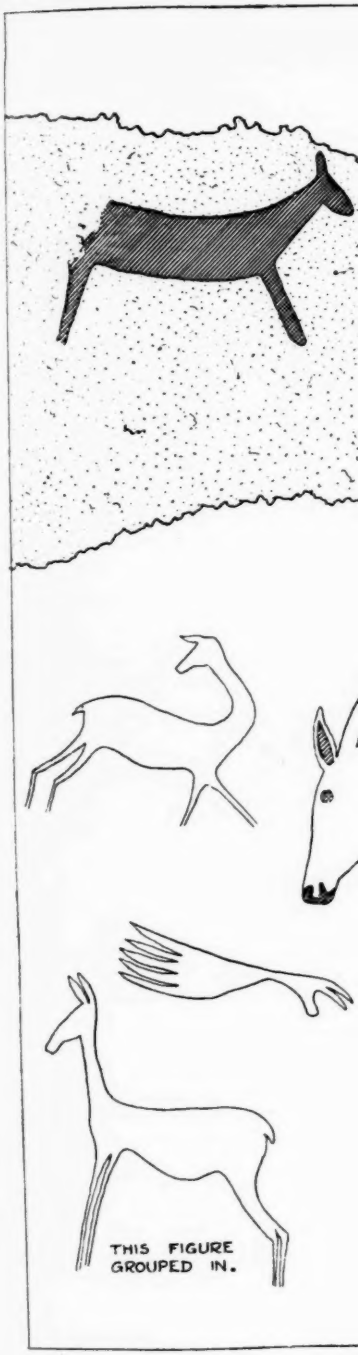
The white (naturalistic) referred to above is extremely old, and the two cases combine to reveal the following sequence of colours and styles, a sequence borne out by the remainder of the paintings:

Black (naturalistic, but not too good)
over
Bichromes and Polychromes (best naturalistic)
over
Pale Yellow (naturalistic) and Red-Brown (naturalistic) and Red Strong (naturalistic)
over
White (naturalistic, extremely old).

In style the ancient monochromes (white, pale yellow, and reds), and the subsequent bichromes and polychromes, reveal a fine naturalistic technique and no uncertain craftsmanship, while the later monochromes, in this instance in black only, are not so good.

An examination of fig. 2 shows that the figures in white (not directly superposed here)—especially the two small antelope in the lower left corner—are particularly well drawn. These belong to the most ancient series in the shelter and are readily distinguished from later whites that appear elsewhere. The pale yellow figure under the bichrome and polychrome is equally naturalistic in technique and finish, while the succeeding polychromes represent the acme of artistic feeling and finish in the art of the cave-dweller, inasmuch as they are truly representative of the finest works we possess. When, however, we arrive at the entirely superposed monochrome in black, we find that, although it is still naturalistic in treatment, the art is clumsy and degenerate. It is also obvious that this black figure is separated from the underlying figures by a considerable lapse of time, inasmuch as it appears on a well-patinated surface exposed only after the scaling-off of a patch of rock from the underlying bichrome and still more ancient yellow monochrome. While we have no idea how much later the best naturalistic bichromes and polychromes are than the underlying and therefore still more ancient monochromes (white, yellow, and red), we can say that the later black is very much more recent than either.

Following the Abbé's lead, we see that the black naturalistic figure belongs to the Later Period of Rock-painting, and the remainder forms


THIS FIGURE
GROUPED IN.

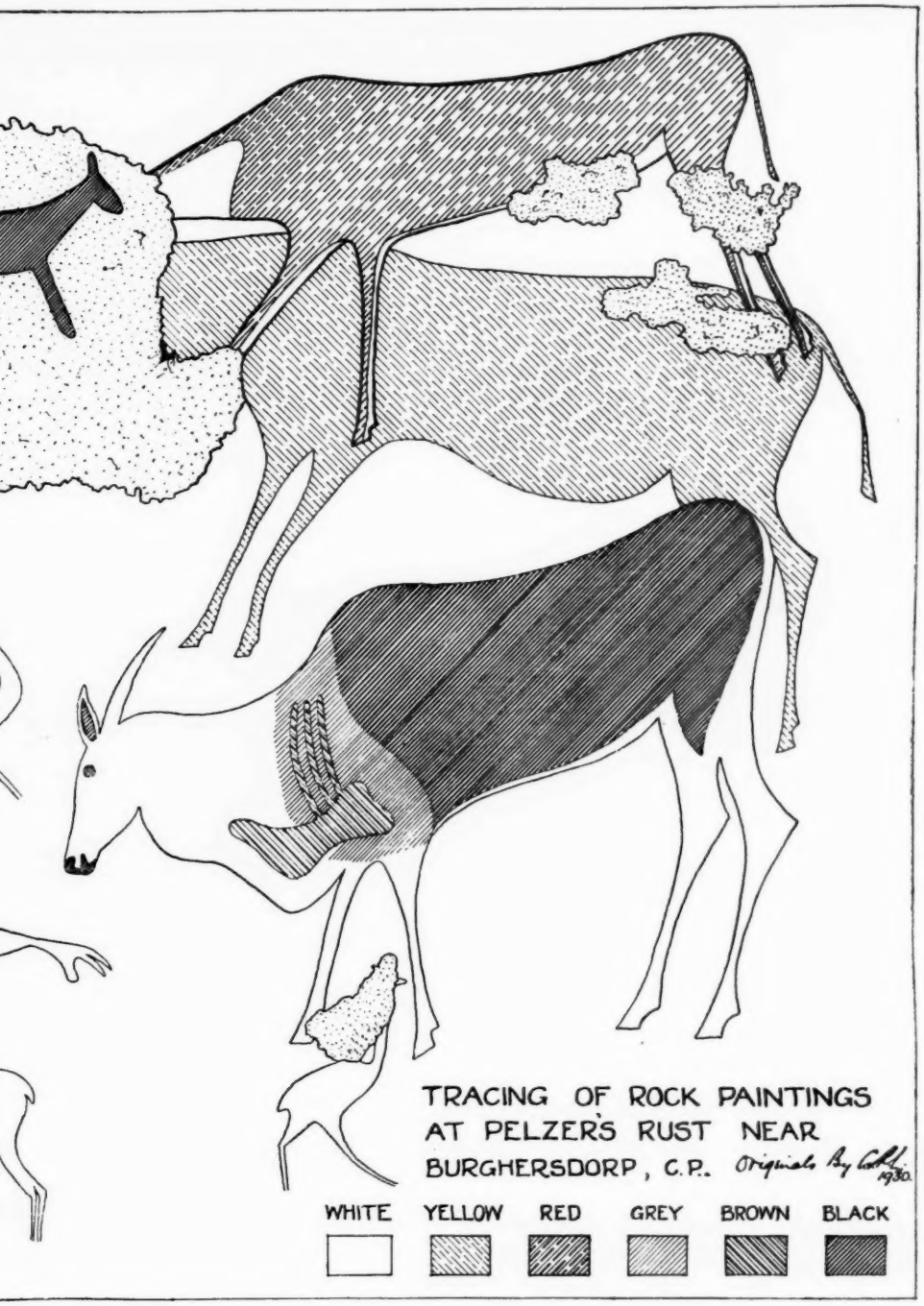


FIG. 2.

[*To face p.* 54.

Table of Analyses of Prehistoric Rock-paintings.

	Ventershoek (Christol Cave).	Modderpoort.	Ladybrand.	Schaapplaats.	Pelzer's Rust.
Later Period.	Red-Orange. Without form				
	Black-White. Diagrammatic	Black-White. Diagrammatic	White-Black. Diagrammatic	Black. Diagrammatic	
	Yellow-Ochreous Strong ± Naturalistic			Yellow-Ochreous Strong ± Naturalistic	
	Red, Strong. ± Naturalistic			Red, Strong. ± Naturalistic	
	White or Black. ± Naturalistic	Black and White. ± Naturalistic			
	Polychromes (*a*) Bad Art (*b*) Better Art				
	Black. Naturalistic	Black. Naturalistic	Black. Naturalistic		Black. Naturalistic
Earlier Period.		Beautiful Polychromes (White, Yellow, Red, Brown, Black)	Beautiful Polychromes (White, Yellow, Red, Brown, Black)	Beautiful Polychromes (White, Yellow, Red, Brown, Black) and Bichromes (D. Red and White)	Beautiful Polychromes (see fig. 2)
		Men in Red Chocolate with White details			Red-Brown, Strong Red and Pale Yellow.
		Black	Black	Red enough, Strong	Strong Red
	Red, Pale	Red, Pale	Red, Pale	Red, Pale	
				Black	
	Yellow, Pale (legs filiform)	Yellow, Pale	Yellow, Pale	Yellow, Pale	Pale Yellow
		White (filiform)		White	White

a sequence in the Earlier Period, as indicated in the analysis under the appropriate heading.

Of further interest is the fact that the natural ground surface in the immediate vicinity of the shelter, more especially that of the talus spread, is extremely rich in artefacts of the Upper Smithfield Culture. In other words, the latest occupants of the shelter were Upper Smithfield folk, and as they are known to have been artists (4) it is extremely probable that the Later Period monochromes were done by them.

In conclusion, I wish to express my indebtedness to M. l'Abbé Breuil for permission to use the analyses here published. If these prove half as helpful to others as they have been to me, the Abbé will have done prehistoric archaeology yet another great service.

REFERENCES.

(1) TONGUE.—Bushman Paintings, Oxford, 1909.

(2) BLEEK.—Rock Paintings, Methuen, 1930.

(3) OBERMAIER and KÜHN.—Bushman Art, Humphrey Milford, Oxford, 1930.

(4) VAN RIET LOWE.—" South Africa's Place in Prehistory," S.A. Journ. Sci., vol. xxvii, p. 100 *et seq.*, 1930.

(5) (*a*) BURKITT.—South Africa's Past in Stone and Paint, Cambridge, 1928.
(*b*) BURKITT.—Bushman Art in South Africa, Ipek, p. 89, 1929.

(6) VAN RIET LOWE.—" Fresh Light on the Prehistoric Archaeology of South Africa," Bantu Studies, vol. iii, No. 4, 1929.

(7) BREUIL.—" Premiers Impressions de Voyage sur la Préhistoire Sud-Africaine," l'Anthropologie, t. xl, 1930.

In this, his first " official " contribution to the subject, l'Abbé Breuil recognises two Periods comprising seventeen phases in the area under review. The first eight phases combine to form the Earlier Period, in which the art is entirely naturalistic and essentially produced by a hunting people ; the later nine combine to form the Later Period, in which the art, on the whole, is degenerate, less naturalistic, and produced often by pastoral folk. Breuil recognises three geographical groups : Group I, Rhodesia ; Group II, the Eastern Orange Free State and Western Basutoland ; Group III, the Cape Province, and draws most illuminating comparisons between the various phases of the three groups.

(8) *Compare* HEWITT.—" Discoveries in a Bushman Cave at Tafelberg Hall," Trans. Roy. Soc. S.A., vol. xix, pt. 2, p. 185, 1931.

Also HEWITT and STAPLETON.—" On Paintings and Artefacts in Rock Shelters near Cala," Records Albany Mus., vol. iv, 1930.

A RARE POINT FROM SHEPPARD ISLAND.

By C. van Riet Lowe.

(With one Text-figure.)

To those who have followed the excavations at Sheppard Island * it is interesting to note that during this, my third year of work, the wealth of the remains recovered continues undiminished. Very many beautiful specimens of Lower and Upper Stellenbosch (Chelles and Acheul types), Fauresmith (La Micoque type), and Middle Stone Age (Mousterian and Solutreo-Mousterian types) have recently been added to the main collection housed in the University of the Witwatersrand, and it has now become apparent that more than one phase of the Middle Stone Age is represented. The confused manner in which the latter remains have been deposited does not yet admit of any definite sorting of Middle Stone Age types into industries, and all we have to guide us is relative rolling, or weathering, and technique. To the former we can, under the circumstances prevailing, unfortunately not always attach much significance, but, combined with technique, it is occasionally possible to say "this specimen or this lot is very much more recent than that ; the weathering is lighter and the technique more evolved."

The point I have chosen to describe apparently belongs to a late phase of the Middle Stone Age—perhaps even to an early phase of the Later Stone Age. Though recovered from a depth that yielded typical Middle Stone Age types, the comparative freshness of the implement, combined with parallel longitudinal flaking and a definite Still Bay or "Solutrean" retouch, incline one to regard it as belonging, most probably, to the Middle-Later Stone Age transition.

An examination of the illustration makes it immediately apparent that we have before us a very rare and, I may add, beautiful point trimmed and shaped for hafting. The material is lydianite, and the edges unusually sharp and fresh. It will be noticed that fine secondary trimming is confined

* (*a*) "A Few Notes on the Archaeology of Sheppard Island," Ann. S.A. Mus., vol. xxvii, p. 235. (*b*) "Further Notes on the Archaeology of Sheppard Island," S.A. Journ. Sci., vol. xxvi, p. 665. (*c*) "Fresh Light on the Prehistoric Archaeology of South Africa," Bantu Studies, vol. iii, No. 4.

to small portions near the point and to a considerable portion of the butt-end, the latter revealing a Still Bay retouch. The flake surface is entirely flat, the bulb having been removed. In the text-figure I have made an attempt to show the probable development of the implement from its parent flake. The outer broken line shows what may have been the original flake in outline. First the bulb end was removed by a single blow, thus leaving the portion below the line AA. Then, by a series of blows delivered on the flake surface, the portions adjacent to AB, BC, CD, DE, etc., were removed, leaving a blade with an unsatisfactorily eccentric point and clumsy butt-end.

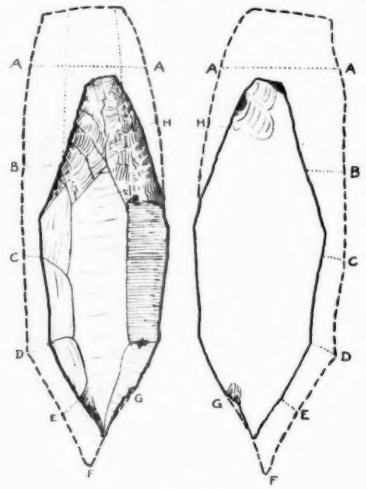


FIG. 1.

The point was then skilfully trimmed to the shape required (first on one side, then on the other) and the butt-end worked down until it became suitable for hafting, this final flaking having been "pressure" throughout.

The implement is by no means an unfinished Still Bay point, and where, on first inspection, one may incline to classify it as "belonging" to this industry, it must be emphasised that it is a "finished" product ready for use, from an area entirely remote from those that have yielded Still Bay assemblages.

The material used, the technique employed, and the comparative freshness of the specimen enable us with little uncertainty to fit it into that phase of the Stone Age that is represented by the Middle-Later Stone Age transition, or by the earliest disturbance of palaeanthropic by neanthropic man on the great uplands of the Union.

THE ALKALOIDS OF THE BARK OF *STRYCHNOS HENNINGSII* (SECOND COMMUNICATION).

By M. Rindl.

(Department of Chemistry, Grey University College, Bloemfontein.)

In my first publication on the chemistry of the bark of *Strychnos Henningsii* I described the isolation of a crystalline alkaloid by repeated extraction of an acetic acid solution of the alkaloid mixture with chloroform.* In this way only a very small portion of the total alkaloids was obtained.

As there appeared to be a possibility of the bark being of therapeutic interest, the chemical works of Messrs. E. Merck of Darmstadt, Germany, kindly offered to carry out a bulk extraction and to undertake the necessary pharmacological tests.† A quantity of plant material was accordingly obtained, through the courtesy of the Division of Forestry of the Union, and sent across in August 1930. The results of the chemical investigation carried out by the Scientific Department of the firm, and which agree in most respects with my own findings, indicate that the bulk of the alkaloid mixture is amorphous. The earliest attempts at isolating these alkaloids, which were carried out at the Imperial Institute,‡ gave only a gummy mass. My numerous attempts at obtaining the major portion of the alkaloid, or derivatives thereof, in a crystalline form were equally unsuccessful. The

* South African Journal of Science, vol. xxvi, pp. 50–56, 1929.

† The alkaloids from *Strychnos Henningsii* are much less toxic than strychnine and have a different action. Whilst in the case of strychnine 0·0005 mg. per grm. of body weight produces convulsions and death in mice, the lethal dose of the amorphous alkaloid from *Strychnos Henningsii* is 0·25 mg. per grm., and death is preceded by paralysis.

The lethal dose for the frog by the ventral sac is 0·5 mg. per grm. body weight.

The alkaloid lowers the blood-pressure and has a depressing effect on the vaso-motor centre. It differs pharmacologically from strychnine in acting on the medullary centres and not on the spinal cord. The toxic effect of the alkaloid is mainly on the respiratory centre, and death results from central paralysis.

The toxicity of the crystalline alkaloid is approximately the same as that of the amorphous alkaloid, but it appears to have no action on the blood-pressure and respiration.

In either form the alkaloid has no therapeutic value. (Private communication from Messrs. Merck, Darmstadt.)

‡ Bulletin of the Imperial Institute, vol. xiii (1915), p. 30, and vol. xiv (1916), p. 33.

prospects of ultimate success, therefore, appear to be remote. The investigation is not being abandoned, but it seems desirable meanwhile to place a summary of my abortive attempts on record, to serve as a guide to anyone who may be tempted into an investigation of these alkaloids.

Liberation of the Base.

As other solvents than chloroform (benzene, amyl alcohol) failed to remove anything from the acid solution, this solution, prepared and purified as described in my first publication, was rendered alkaline with ammonia and extracted repeatedly with chloroform. On addition of aqueous ammonia the solution darkens and a curdy yellow precipitate is thrown down. On one occasion, when strong ammonia was used in place of the dilute aqueous solution, the observation was made that the supernatant liquid developed a dark green colour. On other occasions, when chloroformic or alkaline aqueous solutions were left freely exposed to light and air for prolonged periods, resinification and colour development took place. The combined chloroformic extracts were washed with small amounts of water, dried over anhydrous sodium sulphate, and the solvent removed. The amount of crude base obtained in this way was equivalent to over 5 per cent. of the bark. Mercks purify the base *via* the sulphate and record a yield of 2·8 per cent. of the purified base. The residue from the chloroformic extract was a colourless varnish, which turned into an almost white powder on triturating with ether. As it proved to be slightly soluble in this solvent, the base was divided into an ether-soluble and an insoluble fraction by repeated treatment with small quantities of ether. Numerous attempts were made to crystallise these fractions from single solvents and from mixtures of solvents, but in all cases with negative results.

Other and weaker bases were substituted for ammonia (potassium bicarbonate, barium carbonate, calcium carbonate, followed by ammonium carbonate), and the solutions thus alkalinised were extracted repeatedly with different solvents (benzene, chloroform, ether). When liberating the base with potassium bicarbonate, endeavours were made to minimise the possibly deleterious effect of the air by extracting with chloroform in an atmosphere of nitrogen, and distilling off the solvent in the same indifferent atmosphere under reduced pressure (15–20 mm.). Not only were the residues left on removal of the solvents in all cases amorphous, but it is evident from the wide melting range that these products were all complex mixtures. Continuous percolation with ether failed to effect any purification, and endeavours to obtain crystalline derivatives (sulphate, picrolonate, hydrochloride, hydrobromide) were equally unsuccessful.

Fractional Precipitation.

In view of the observed complex nature of the crude alkaloid it seemed not improbable that fractional precipitation might effect a partial separation. Nine fractions were obtained by successively adding small amounts of dilute ammonia solution to the aqueous acid solution and extracting each time with chloroform. The residues left after removal of the solvent were pasty, sometimes even liquid. On stirring thoroughly with ether the resinous residues set to a cream-coloured powder. Those fractions which were obtained in sufficiently large amount were extracted by continuous hot percolation, first with dry ether and subsequently with benzene. The residues proved refractory to all attempts at crystallisation. The melting-point of all fractions, both before and after treatment with solvents, covered a wide range. As the results of the attempts to obtain homogeneous products from the individual fractions were not encouraging, and as there were no indications of any essential differences in composition between the individual fractions, further endeavours to isolate the constituents of the alkaloidal mixture by fractional precipitation were abandoned.

Conversion of the Base into the Sulphate and Regeneration from the Sulphate.

The chloroformic extracts of the ammoniacal solution were repeatedly shaken up with small amount of a 1 per cent. sulphuric acid solution. Whilst the sulphuric acid solution was markedly acid in reaction after the first extraction, the alkaloid had not been completely extracted from the chloroform solution, indicating considerable hydrolysis of the sulphate. The chloroform solutions were therefore shaken up several times with fresh portions of the acid. In one case five extractions with fresh lots of acid were necessary for the complete removal of the base. As the sulphuric acid extracts obtained in this way were very dilute and contained a considerable excess of acid they were used repeatedly for extracting fresh lots of the chloroform solution. Subsequently it was ascertained that the incomplete extraction of the chloroformic solution, by shaking with dilute sulphuric acid, was due to the presence of small amounts of the crystalline alkaloid previously described, the bulk of which was obtained from the acid aqueous solution.

The sulphate solutions were concentrated over calcium chloride in a vacuum desiccator and always gave light brown, brittle, amorphous residues. On one occasion I found that the 1 per cent. sulphuric acid solution, which had been standing for a long time freely exposed to light and air, was coloured bluish, and on concentration the solution turned dark blue, almost

black. On another occasion a solution which had been exposed for a shorter time developed a distinct mauve tint. This colour-change is interesting in the light of the behaviour of the vomicinic acid derived from the new strychnos alkaloid vomicine.* Whilst the alkaline solutions of the salts of vomicinic acid turn green, the colour-changes in my case were observed in acid solution, suggesting the presence of a constituent more subject to auto-oxidation than vomicinic acid. On rendering the aqueous solution of the sulphate alkaline with ammonia and extracting with chloroform the base (henceforth known as regenerated base) is obtained as a brown varnish, which turns into a sand-coloured powder on stirring thoroughly under ether. The base itself appeared to be no purer than the alkaloid before conversion into sulphate and regeneration, and attempts to purify with the aid of solvents (benzene, dilute alcohol, ethyl alcohol plus ether, methanol, methanol plus ether) did not lead to crystalline or homogeneous products.

Endeavours to obtain a purer base by gradual precipitation of the sulphate with gaseous ammonia were equally unavailing. Open dishes of the aqueous solution of the sulphate and of strong aqueous ammonia were placed side by side in a desiccator. Overnight a granular deposit was formed which was sufficiently coherent to be lifted out in flakes, but which proved very impure and could not be induced to crystallise. No better success was achieved by retarding the process by using a very dilute aqueous solution of ammonia.

In view of the possibility of amorphous products exercising an inhibiting effect on the tendency of the bulk of the base to crystallise, an alcoholic solution of the regenerated base was boiled with norite, filtered, and allowed to evaporate slowly in a desiccator. This process was repeated three times without indications of any success.

Attempts to purify the regenerated base by conversion into salts (hydrochloride, picrate, nitrate, carbonate) gave equally discouraging results.

Bromination.

The alkaloid is apparently of so unstable a nature that it immediately undergoes change on liberation from aqueous solution. In the hope of obtaining a stable and possibly crystalline product, bromination of the alkaloid in the original aqueous solution was resorted to. A similar method had proved successful in the case of the new strychnos alkaloid vomicine.† A saturated aqueous solution of bromine was run in from a burette, with or without the addition of an alkaline medium to the aqueous solution (sodium carbonate, precipitated calcium carbonate). A large number of titrations

* Annalen 469, vol. iii (1929), p. 202.

† *Ibid.*, p. 203.

were made, but it was impossible to obtain even approximately concordant figures. At first the temperature was kept in the vicinity of 20° C. In the later titrations it was kept down to 5–10° C. by addition of ice. A light yellow precipitate is formed where the bromine solution enters the liquid, but disappears on shaking. Even when an amount of bromine considerably in excess of the quantity calculated as theoretically necessary for bromination had been added, the precipitate did not persist. Moreover, in most cases there appeared to be no recognisable or well-defined end-point. (Potassium iodide-starch as indicator.) Finally, a number of different products could be extracted from the aqueous solution by shaking with immiscible organic solvents (shaken with benzene, chloroform, amyl alcohol, before and after addition of excess of sodium carbonate). Some of these were entirely devoid of bromine. It would seem, therefore, that in place of a homogeneous brominated product a number of oxidation products were obtained. The method was, therefore, abandoned as not likely to lead to positive results.

Benzoylation.

The colour formation previously referred to is possibly due to the presence of a hydroxyl group in para position to a lactame group, and the consequent tendency to form compounds of a quinonoid type. This tendency might be overcome by fixing the hydroxyl group by benzoylation. Hence I endeavoured to benzoylate the regenerated base (1) in aqueous solution in the presence of sodium hydroxide, (2) in pyridine solution, (3) in benzene solution without use of any additional base. I also endeavoured to benzoylate the acid aqueous solution, as well as the base freshly extracted by chloroform from the original solution rendered alkaline by barium carbonate. There is so much similarity between the untreated base and the product recovered after attempted benzoylation as to suggest that the two products are identical and that no benzoylation has taken place.

High Vacuum Sublimation.

A preliminary micro-sublimation with the regenerated base indicated the possibility of partial purification by this method. At 120° C. (0·0025 mm. pressure, McLeod gauge) a slight crystalline sublimate was obtained. At the same time the material in the heated portion of the tube was in a state of vigorous motion as though it were boiling (*Siedesublimation* *), and swelled up to a spongy mass occupying a much bigger bulk than the original material.

* Houben, Methoden der organischen Chemie, i, 670.

On repeating on a larger scale (0·6 grm.) the material seemed to undergo explosive disintegration, shooting up in the sublimation vessel and finally filling the greater part of the tube. This violent decomposition process is accompanied by a rise in pressure. On one occasion a rise up to 0·2 mm. was registered. The pressure rapidly sank again, indicating the liberation of a gas which is almost instantaneously removed. The amount of crystalline sublimate was small, and it was impossible to separate it completely from the bulky cream-coloured decomposition product which had been scattered through the entire tube. The sublimate is alkaloidal, forms well-developed crystals, and melts at about 135–140° C. The residue of the high vacuum sublimation was extracted by continuous hot percolation with ether and benzene. The extracts obtained were resinous, and neither from them nor from the insoluble residue could anything crystalline be obtained.

In order to ascertain the nature of the gas liberated on decomposition of the alkaloid a small amount was heated under reduced pressure (35 mm.), and the liberated gas passed through barium hydroxide solution. At 120° C. decomposition began. The base was heated up to 165° C. At this temperature it was largely decomposed, and there was no indication of turbidity in the barium hydrate solution. Hence the gas evolved is not carbon dioxide.

Further attempts at identifying the gas evolved are being deferred until such time as it may be possible to obtain a homogeneous product on which to study the decomposition under the influence of heat.

The author desires to make his acknowledgments to the Research Grant Board for a grant, part of which was used to defray the expenses of this investigation. He also desires to record his indebtedness to Messrs. E. Merck, of Darmstadt, for carrying out pharmacological tests.

CRYSTALS FROM THE KIMBERLEY MINES.

By E. D. Mountain, M.A.

(Professor of Geology and Mineralogy, Rhodes University College, Grahamstown.)

(With Plate I and twelve Text-figures.)

The Kimberley diamond mines are a veritable museum of rocks and minerals, and owing to the almost unique type of occurrence of the diamonds and the enormous quantities of the precious stone discovered there, the mines have already received a considerable amount of attention from scientists. The most recent and comprehensive scientific treatise on the subject is P. A. Wagner's The Diamond Fields of Southern Africa (1914), and his second chapter, considering the nature of the book, gives in some detail a description of the individual minerals occurring in the mines. Little idea, however, is given in that book of the beauty and magnificence of the crystallised specimens which have been obtained from the mines, and little of their infinite variety. Indeed, except in the case of the diamond itself, practically no crystallographic description of any mineral has been attempted.

The present investigation of the mine-minerals was undertaken at the suggestion of Miss M. Wilman, the Curator of the McGregor Museum, Kimberley, where the finest representative collection of these minerals in the world is to be seen. I take this opportunity to thank her for all her help, and also to acknowledge assistance from the Research Grant Board enabling me to visit Kimberley on more than one occasion. I am also indebted to Mr. A. F. Williams, General Manager of De Beers Consolidated Mines, Ltd., who has greatly facilitated this work in providing both material and information.

The mineral-specimens obtained from the mines, with the exception of those, such as epidote, fluor, and actinolite, which have been obtained from the country-rock comprising the walls of the pipes, fall into four categories so far as their origin is known. First, there are the primary constituents of the kimberlite-magma, and I have somewhat arbitrarily included diamond under this heading. Secondly, there are the constituents of the cognate xenoliths; and thirdly, minerals derived from, and possibly still associated

with, accidental inclusions. Lastly comes the group which has chiefly contributed to the wealth of specimens found in museums, the secondary minerals—that is, those crystallised subsequent to the consolidation of the kimberlite.

Only a few of the original constituents of the kimberlite-magma are both idiomorphic and large enough to be regarded as crystal-specimens, and of those with which I am acquainted, all have received attention in Wagner's book. For instance, he mentions *phlogopite* in idiomorphic hexagonal plates (p. 57), minute yellowish octahedra of demantoid *garnet* (p. 65), and dirty-green perfect trapezohedra, possibly also demantoid, from Sekretaris Mine (p. 65). A number of crystals in the McGregor Museum (No. 3260) from Sekretaris also consist of icositetrahedra up to 3 mm. in diameter, and possess crystal-faces of the form (211) which give good reflections, although frequently striated in such a way as to resemble lamellation parallel to the rhombic dodecahedron. They are pale-yellow in colour, varying from a greenish yellow to amber, and would seem from their properties also to be a variety of andradite, and in view of the colour perhaps the name topazolite would be most appropriate.

Sharp-edged octahedra of *magnetite* up to $\frac{1}{4}$ inch diameter from the Premier Mine near Pretoria are mentioned (p. 72), and also bright octahedra of *picotite* and *chromite* of the same size (p. 72), found in the concentrates of most mines.

Mr. Alpheus Williams is said to have in his possession a perfect *zircon* crystal from the Dutoitspan Mine (p. 72). This statement probably refers to a somewhat rounded crystal about 15 mm. long and 10 mm. across. It is pale amber in colour and appears to show the forms (110) and (111), with indistinct cleavages parallel to both.

Small barrel-shaped crystals of *ruby* with steep hexagonal bipyramid and basal pinacoid from Koffyfontein are mentioned on p. 73.

Finally, among the primary constituents, the *diamond* alone appears to have received any considerable attention with regard to its crystallographic development. Wagner gives a brief summary of the work of Fersmann and Goldschmidt, while J. R. Sutton in a more recent work * has devoted at least four chapters to the morphology of the diamond. There are, however, still further crystallographic features of the diamond, illustrated by specimens in the collection of Mr. A. F. Williams, which deserve notice.

A black opaque tetrahedral crystal with sharp edges, measuring 4·5 mm. along the edge, appeared at first sight to be a simple tetrahedron with certain of the edges modified by faces of a triakis-tetrahedron. The faces, although badly pitted with shallow triangular depressions and studded with rounded bosses, gave perfect reflections, with vicinal faces giving fainter

* J. R. Sutton, Diamond, 1928.

reflections, in zones mutually inclined at 120°, at about 4½°. It was noted, however, that the triangular pits on two faces were oriented parallel to the outline of the face, while on the other two faces they were in an inverted position. This suggestion of twinning was supported by the existence and orientation of similar triangular depressions on the narrow faces truncating the edges of the tetrahedron, as shown in fig. 1, and was definitely established by measuring the angle between these narrow faces and the adjacent tetrahedron faces, a theoretical angle of 38° 56′. The specimen is thus twinned on two of the tetrahedral faces, but it cannot be regarded as a simple reflection or rotation twin derived from the tetrahedron, because the smaller tabular individuals show octahedral development. The major individual must therefore be regarded as a distorted octahedron. In the figure the three individuals can be distinguished by the shading, and the twin-planes in this orientation correspond with $(\bar{1}\bar{1}1)$ and $(1\bar{1}\bar{1})$. The orientation of the triangular depressions is shown diagrammatically.

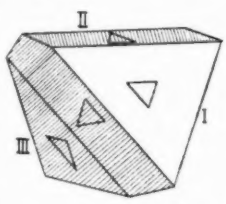


FIG. 1.—Diamond twinned on $(\bar{1}\bar{1}1)$ and $(1\bar{1}\bar{1})$.

This mode of twinning, *i.e.* on two faces of a tetrahedron, was not confined to this crystal, but was observed in three other similar triplets consisting of transparent crystals with somewhat rounded faces. In the case of the black specimen mentioned first, one coign shows unmistakable signs of a re-entrant angle, but in the others no such feature is present.

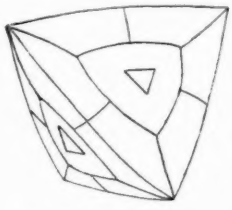


FIG. 2.—Untwinned tetrahedral crystal of diamond.

Much discussion has raged in the past over the tetrahedral crystals of diamond, but although no perfect tetrahedron of diamond has come to my notice, two crystals in Mr. Williams' collection represent rounded tetrahedra modified by curved faces of vicinal hexakis-tetrahedra, and one of them shows imperfect triangular pits in the centre of the tetrahedron faces, which from their orientation indicate an absence of twinning (see fig. 2). Moreover, there is no sign of the presence of negative forms except possibly a slight rounding of the coigns.

A second type of twinning appears to merit description and is shown in fig. 3. It consists of a spinel-twin with a somewhat complicated though well-defined composition surface. This surface comprises three planes parallel to different octahedral faces, including the twin-plane, and might for example be defined, for the orientation adopted in the figure, as (111) and $(11\bar{1})$ of the normally oriented individual together with $(1\bar{1}1)$ of the

rotated individual. It will be seen, then, that all the planes comprising the contact-surface cannot be referred to either individual alone. Fig. 3, *a*, represents a projection on the twin-plane, fig. 3, *b*, is a clinographic drawing of the contact-surface, and fig. 3, *c*, is an elevation-drawing of the crystal, as seen from the left of fig. 3, *a*. In fig. 3, *a*, the full-lined triangles represent diagrammatically the orientation of triangular depressions on the upper surfaces, and the broken-lined triangles those on the lower surfaces.

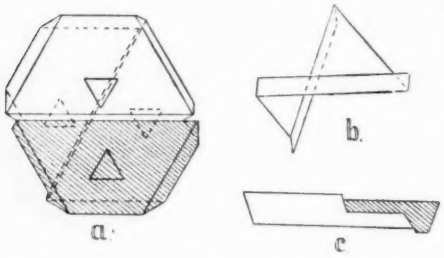


FIG. 3.—Spinel twin of diamond showing peculiar contact-surface.

Finally there is the multiple twin, or possibly only an interpenetrant twin, known commonly as a star. This really consists of two tabular spinel twins superimposed with a relative rotation between them of 180° about the twin-axis. Thus instead of the second and fourth individuals from the bottom being in parallel position, as would be the case if both twins had the same orientation, the second and third are parallel and so are the outer individuals. In fact, in some cases, the parallel individuals tend to merge into a single crystal. In a sense, therefore, the star may be regarded as a twinned twin or double twin, and morphologically this appears to represent the conditions better than regarding it simply as an interpenetrant twin, which is geometrically correct. Dana * gives an illustration of what appears to be identical with the star, but he gives no description of it. Sutton † figures a similar specimen and calls it a peritropic twin, an expression which is not defined. From his description, however, it seems possible that he is dealing with something different from the above, which is shown in plan and elevation in fig. 4 (*a* and *b* respectively).

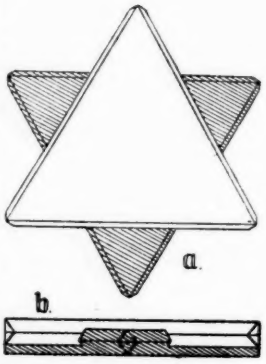


FIG. 4.—Star-twin of diamond.

Certain primary constituents of the kimberlite-magma normally occurring in anhedral crystals show crystal-facets when enclosed in other minerals.

* E. S. Dana, System of Mineralogy, 6th edition, 1892, p. 3, fig. 6.

† *Loc. cit.*, pl. xvi, opp. p. 30.

Such, for example, are pyrope enclosed in diamond and also chrome-diopside enclosed in garnet, but the crystals in such cases are small and the occurrences seem to be rare.

Of the mineral-constituents of the cognate xenoliths, diamond alone is mentioned by Wagner as occurring in megascopic idiomorphic forms : " The diamonds, which range up to one carat in weight, are always in the form of sharp-edged octahedral crystals built up of superimposed laminae. In contradistinction to the majority of the diamonds found in the kimberlite, they show no sign of solution or corrosion."

Cyanite crystals, especially some from the Roberts Victor Mine, O.F.S., although rounded, also show unmistakable crystal-facets. They measure up to 5 mm. in length, are somewhat prismatic, and show the forms *a*(100), *m*(110), M(1$\bar{1}$0), and *b*(010) with rounded indeterminate end-faces.

A few minerals, although generally not well crystallised, appear to be related definitely to foreign inclusions. Among them are the sulphides *molybdenite, galena,* and *chalcopyrite,* specimens of which consist of small rounded masses about 1 cm. in diameter, and which appear in all cases to be material derived from the grease-tables. The molybdenite occurs with vein-quartz containing also a little chalcopyrite, and may possibly represent either foreign material or secondary veins in the kimberlite. The galena is usually isolated and in rounded cubes, probably cleavage-forms, but in one specimen it was partially embedded in a granular magnesian limestone or dolomite. Most of the chalcopyrite, on the other hand, represents an impregnation and replacement-deposit in a somewhat coarse-grained quartzose sediment with a calcareous cementing material. Both the galena and the chalcopyrite therefore show evidence of foreign origin, but so far as I am aware, the nature of the occurrence of these minerals in the kimberlite is not known.

Small, beautiful doubly-terminated *quartz* crystals are well known in the mines, and good specimens are shown in the McGregor Museum from Bultfontein, Sekretaris, and Jagersfontein. Although secondary quartz does occur associated with the other secondary minerals, it in no way resembles these small, well-formed crystals, and it seems probable that they are of foreign origin. Indeed, they resemble the quartz crystals commonly found in the Karroo formations. These crystals show only the usual prism and rhombohedral faces, there being no evidence of trigonal symmetry.

A specimen of *aragonite* in the Albany Museum (No. 1028) from the Kimberley Mine appears to be unique. It consists of a vein of fibrous or columnar material about 2 inches long, the fibres being broken up in part by radiating groups of acicular crystals, and also by occasional partings of shaly or fine sandy material arranged perpendicular to the length of the

fibres. It would thus seem that the specimen as a whole is a foreign inclusion probably from the Karroo formations. It was obtained from about 80 feet below the surface, and is said to come from the yellow ground.

A *garnet* crystal from Koffyfontein (McG. Mus. 1056), unlike the normal garnet of the kimberlite, shows well-developed rhombic-dodecahedron habit, and is somewhat elongated, measuring 4 cm. in length and 3 cm. across. Its refractive index, colour, and specific gravity are typical of almandine, and adhering flakes of a silvery mica further differentiate it from pyrope. It seems probable that this large crystal and other similar crystals are derived from a mica-schist of foreign origin.

Wagner has given a brief description of the *secondary minerals* (p. 73), but to this list might be added marcasite, orthoclase, pectolite, celestine, anhydrite, and gypsum. Also, since Wagner's description of these minerals was published, afwillite, a new hydrated calcium silicate from Dutoitspan Mine has been described,* and there are probably at least two further related minerals from this mine still to be described.

The commonest of the secondary minerals are calcite, apophyllite, and natrolite, which frequently occur in association. They usually form crystalline crusts on foreign inclusions, notably Karroo dolerite, sometimes lining cavities and sometimes acting as a cement between fragments of an inclusion. In fact, most of the crystalline specimens from the Kimberley mines are associated with enormous dolerite inclusions, although some specimens of calcite and apophyllite have crystallised direct in the kimberlite. Most of the specimens were obtained from the upper levels, practically no good specimens of apophyllite having been found beyond a depth of 1000 feet. The calcite crystals alone seem to persist in depth, and good specimens have been found as deep as 3000 feet.

The nature of the association of these secondary minerals appears to be fairly constant. The matrix is usually encrusted with pectolite, natrolite being the next mineral to crystallise. The natrolite needles, however, very often penetrate a portion of the pectolite tufts, suggesting the continued crystallisation of the latter during the formation of the natrolite. Apophyllite is generally, but not always, subsequent in formation to pectolite, the crystals usually being disposed on the pectolite crust. The apophyllite may be, however, contemporary with the natrolite, as the association of these two minerals is uncommon and the sequence is even then in doubt. The calcite crystals appear to be the last of the secondary minerals to crystallise, although small pyrite crystals are sometimes found coating them.

Calcite crystals are universal in their occurrence, but most of the other specimens of secondary minerals in the McGregor Museum have been

* J. Parry and F. E. Wright, Min. Mag., vol. xx, 1925, p. 277.

obtained from Bultfontein and Dutoitspan Mines. Natrolite and pectolite specimens have also been obtained from Wesselton Mine, and natrolite also from the Kimberley Mine.

Concerning *pyrites* Wagner says (p. 73): "The mineral is particularly abundant in portions of the Premier and Dutoitspan pipes, where fine crystals up to three-quarters of an inch in diameter are of frequent occurrence."

Pyrites crystals do not appear to be restricted in their locality, but exceptionally fine crystals are shown in the McGregor Museum (Nos. 132, 196) from Bultfontein associated with calcite. They measure up to 1 cm. in diameter, and consist essentially of the dyakis dodecahedron $t(421)$, modified by $d(110)$, $e(210)$, and $o(111)$ (see fig. 5). Another specimen of pyrites worth noticing (No. 3643) consists of a group of composite distorted cubes from Blaauwbosch Mine, O.F.S., with the coigns frequently truncated by small faces of the forms $o(111)$ and $n(211)$.

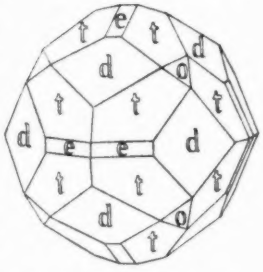


FIG. 5.—Pyrites from Bultfontein Mine.

There is a specimen of *marcasite* in the Albany Museum (No. 272), which comes not from the Kimberley group, but from the Lace Mine, O.F.S. It is a large mass about $3\frac{1}{2}$ inches in diameter consisting essentially of marcasite in typical subradiating cockscomb-like aggregates enclosing coarsely crystalline calcite, with patches of altered kimberlite attached. The marcasite is obviously of secondary origin.

Describing the occurrence of *calcite*, Wagner says that "cavities and fissures lined with fine crystals of this mineral are in evidence in almost every occurrence of kimberlite."

Certain it is that a most extraordinary variety of crystal-development is displayed by this mineral in the Kimberley mines. Among those of dominantly rhombohedral habit, some crystals of the form $e(110)$ are beautifully clear and finely striated parallel to $r(100)$, notably from the Bultfontein and Kimberley Mines. Crystals of the form $r(100)$ are not very common, but the rhombohedron $f(1\bar{1}1)$ occurs very commonly, often tinted yellow, and it usually possesses very curved faces partly subdivided into facets of a scalenohedron $K(32\bar{2})$. This habit often resembles a cube owing to considerable rounding of the polar coigns. Stout prisms, $m(2\bar{1}\bar{1})$, are common, often exhibiting a bluish tint, and may be terminated by dull faces of $e(110)$, by rounded faces of $f(1\bar{1}1)$, or by the basal plane (111). Scalenohedra, sometimes of a deep-yellow colour, are not common.

Only one twin is shown in the McGregor Museum from the Kimberley

group of mines—a large cuboid rhombohedron *f* measuring 2¼ inches along an edge and twinned on the face *c*(111). This twin (No. 392) comes from De Beers Mine.

A somewhat similar twin (McG. Mus. 2826) was obtained from Lace Mine, O.F.S. It is a very fine, large, isolated specimen of a pale-yellowish tint, and measures 11 cm. in diameter and 5 cm. along the vertical axis. It consists essentially of the rhombohedron *e*(11$\bar{2}$), modified by *m*(2$\bar{1}\bar{1}$) and *v*(20$\bar{1}$), and is twinned again on the basal plane. The individuals are united roughly along the basal plane but overlap to a certain extent.

Many of the calcite crystals are highly modified and had to be measured in order to identify the forms. Some of the more unusual habits are shown in figs. 6–11. The specimen (No. 3547) shown in fig. 10 and in the plate is the finest crystal in the Museum collection. It measures over 6 inches across and, although somewhat turbid in the interior and slightly composite in development, it has beautiful brilliant faces. For clearness in the drawing some of the less important faces of the crystals have been omitted. In all cases the lettering of the faces is that given by Dana in The System of Mineralogy (6th edition), and the orientation has been chosen to show the crystal development to best advantage. The crystals are rotated counter-clockwise through 60° from the position used by Dana, and the Bravais-Miller indices are given below in addition to the Millerian indices in the case of faces not quoted by Dana. The crystals represented in the figures show the following forms approximately in order of diminishing areal development :—

Fig. 6 (No. 211) Wesselton Mine, *f* M Φ *r*.
Fig. 7 (No. 3366*a*) Dutoitspan Mine, *f* L (10.7.$\bar{8}$) = (15$\bar{6}$3) (43$\bar{3}$) = (16$\bar{7}$4).
Fig. 8 (No. 3948) Dutoitspan Mine, *f r m a e c v i h s*.
Fig. 9 (No. 881) Dutoitspan Mine, *a a r f c*.
Fig. 10 (No. 3547) Jagersfontein Mine, *r a a f m v c* (see plate).
Fig. 11 (No. 386) Bultfontein Mine, *v r m e c a* (90$\bar{7}$) = (9.7.$\bar{1}\bar{6}$.2).

Other crystals showing interesting modifications are the following :—

(No. 204) De Beers Mine, *e* (7$\bar{1}\bar{5}$) = (8.4.$\bar{1}\bar{2}$.1) *r m v*.
(No. 451) Bultfontein Mine, *f c* M *r* (531) = (22$\bar{4}$9) (29.17.17) = (4.0.$\bar{4}$.21) *m a x*.
(No. 460) Bultfontein Mine, *m v f r a π c e* (531) = (22$\bar{4}$9).
(No. 2827) Lace Mine, N *r e*.

A specimen of *orthoclase* from Dutoitspan Mine (McG. Mus. 842) seems to be unique. Small bluish-white crystals 3–4 mm. long, with an adularia habit, form a crust on a fairly fresh fragment of dolerite. The crystals are associated with a few brilliant calcite crystals and a thin white

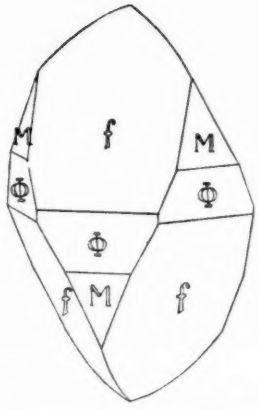


FIG. 6.—Calcite from Wesselton Mine.

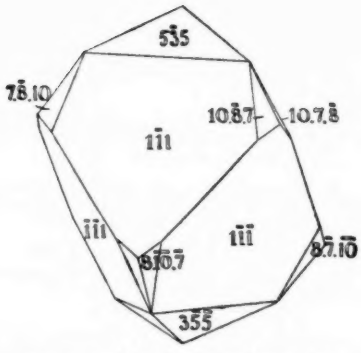


FIG. 7.—Calcite from Dutoitspan Mine.

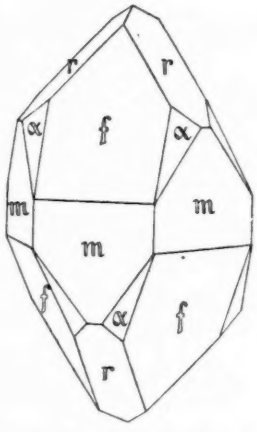


FIG. 8.—Calcite from Dutoitspan Mine.

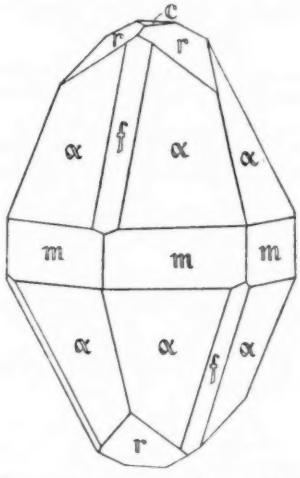


FIG. 9.—Calcite from Dutoitspan Mine.

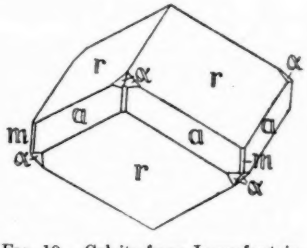


FIG. 10.—Calcite from Jagersfontein Mine.

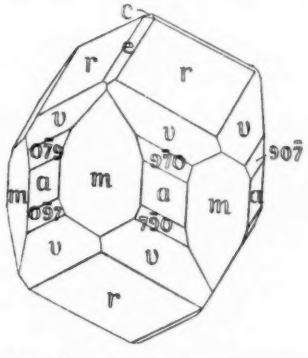


FIG. 11.—Calcite from Bultfontein Mine.

film of an altered zeolite, all three minerals clearly being of secondary origin.

Pectolite, although not mentioned by Wagner, is a common associate of the zeolites in the Kimberley group of mines, and there are many specimens in the McGregor Museum, representing at least Bultfontein, Dutoitspan, and Wesselton Mines. It occurs usually as a fibrous encrustation on foreign inclusions in the kimberlite, but also in radiating masses or tufts and sometimes in isolated spheres. The identification of a specimen of pectolite from the Dutoitspan Mine was established by Mr. John Parry, Chemist to De Beers, who made the complete quantitative analysis given below in Column 1.

Pectolite is also found developed on slickensided surfaces between the kimberlite and the wall of the pipe in the Bultfontein and Dutoitspan Mines. A sample of some such material from the former locality was analysed by Mr. Parry, who showed from his figures, given below in Column 2, that the mineral, if it was originally pectolite, had become much altered by hydration and loss of lime. Indeed the majority of pectolite specimens from the mines, when examined under the microscope, are seen to be considerably altered. The figures in Column 3 give the composition corresponding with the formula $6SiO_2.4CaO.Na_2O.H_2O$, and are added for comparison. Mr. Parry points out that the analysis in Column 1 represents a composition with two molecules of water instead of the one molecule given in the formula quoted.

	1.	2.	3.
SiO_2 . . .	51·52	50·96	54·2
Al_2O_3 } . .	2·20	0·16	..
Fe_2O_3 }			
CaO . . .	32·06	14·80	33·8
MgO . . .	..	0·57	..
Na_2O . . .	9·13	10·00	9·3
H_2O . . .	5·20	22·80	2·7
	100·11	99·29	100·0

The occurrence of *afwillite* has been described by Parry and Wright (*loc. cit.*). It is known only from Dutoitspan Mine, and commonly occurs in columnar masses with a delicate pink tinge of colour.

" The *apophyllite*," according to Wagner, " is generally well crystallised, the habit of the crystal being either pyramidal, combination of (111) and (001), or tabular, owing to the feeble development of the pyramid faces. It

is also seen occasionally to form short rectangular prisms. A somewhat unusual occurrence of apophyllite is described by Henderson * from a kimberlite dyke on Koppiesfontein, near Jagersfontein. Perfect pyramidal crystals of apophyllite, ranging in diameter from 0·5 to 0·8 centimetres, occur scattered like phenocrysts through portions of the blue-ground."

At about the same time as this contribution of Henderson's, James Currie † described and figured tabular crystals rich in faces of the following forms : $c(001)$, $a(100)$, $p(111)$, $m(110)$, and $\alpha(211)$, modified by such faces as $y(310)$, $r(210)$, $z(113)$, and $\phi(227)$. New forms then described were (119), (223), and (332), probably of the nature of vicinal faces.

Large crystals of a similar type have been discovered recently in Bultfontein Mine (McG. Mus. 4173). One of them measures $7{\cdot}5 \times 5$ cm., with a thickness of 6 mm., and consists of the forms c, a, m, y, z, and p. The basal pinacoid is modified by vicinal faces of the form (117), and the crystal shows slight evidence of parallel growth.

Of the Kimberley group, Bultfontein and Dutoitspan alone are represented as localities. The habit of the crystals varies widely, but the association of the forms c, a, and p is almost universal. Two specimens in the McGregor Museum (Nos. 362, 364) from Bultfontein have a peculiar development, as shown in fig. 12, *a*. The crystals are tabular, colourless to white or pale yellow, and about 2 cm. across and 5 mm. thick. Owing to the existence of occasional re-entrant angles between some of the faces, a cursory examination suggests a composite nature for these crystals, and indeed they split up very easily into two similar portions parallel to the base. One of these crystals measured on a two-circle goniometer immediately revealed the presence of twinning. The forms present are $c(001)$, $p(111)$, $a(100)$, $y(310)$, $z(113)$, and $d(115)$, the faces of the form y being alternately developed and common to both individuals, so that the specimen represents a contact-twin with the twin-plane $y(310)$ and the composition-plane $c(001)$. Morphologically perhaps the twin would be better described as possessing a twin-axis perpendicular to the face $y(310)$, since only one-half of each individual is developed. In some cases the twinning is interpenetrant, but it is more commonly contact.

This twin-law appears to be new, the rare twin on $p(111)$ being the only one mentioned in the text-books. An attempt to obtain a Laue radiogram directly through the twin gave an indistinct ring of eight spots instead of the usual four, thus confirming the composite nature of the specimen. The edges between faces of the forms y and c are frequently bevelled by indistinct faces inclined to the base at an angle of $26\frac{1}{2}^\circ$ and corresponding roughly with

* J. A. L. Henderson, Min. Mag., 1897, vol. xi, p. 318.

† J. Currie, Trans. Edin. Geol. Soc., 1897, vol. vii, p. 252.

the form (318), and in this case the *y* faces are no longer continuous in both individuals but separated by a groove.

The optical properties of these twins are rather peculiar. When an isolated individual of a twin is examined between crossed-nicols in parallel light, it is seen to be divided up into sectors as shown in the diagram (fig. 12, *b*). The square centre-portion shows no interference-colours, while the marginal strips which run parallel to the alternate faces of the form *y*(310) are weakly birefringent. These strips have not got straight extinction, but extinguish at $56\frac{1}{2}°$ measured clockwise, in the case of the upper individual, from the direction of their length. The extinction position is not very well defined, but does not vary through more than 4°. In convergent light the central area is seen to be uniaxial positive in character, and the marginal strips biaxial positive, except at the corners where they meet and become locally uniaxial. The planes of the optic axes of adjacent strips are mutually perpendicular, and correspond roughly with the trace of faces of the form $(5\bar{1}0)$. The optic axial angle does not exceed a value of $2V = 40°$, but is commonly about this size.

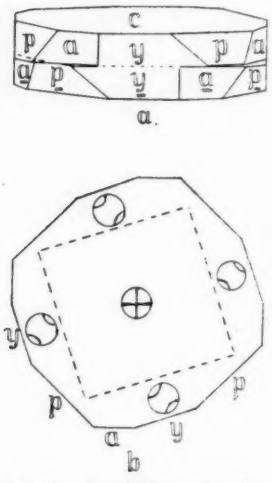


FIG. 12.—Apophyllite twinned on (310) from Bultfontein Mine.

Natrolite occurs only as prismatic crystals, extremely slender or acicular in habit, and usually radiating or in tufts. Its occurrence in the Kimberley mines does not appear to be so restricted as that of apophyllite.

A crystal (McG. Mus. 383) from Bultfontein was measured and found to consist of the forms *a*(100), *m*(110), *o*(111), and *t*(511). It measured 3 mm. long and 1·5 mm. thick.

The largest perfect crystals in the McGregor Museum come from the Wesselton Mine (No. 3574). They are 2·5 cm. long and 3 mm. thick, with the forms *a*, *m*, *o*, and are disposed in radiating groups on a crust of pectolite.

Mr. Alpheus F. Williams has in his collection a fine crystal of *barytes* from Dutoitspan Mine. It is prismatic in habit, being highly modified at one end and broken at the other along the basal cleavage. The crystal measures 3·3 cm. along the vertical axis and 3·5 cm. along the macro-axis. The forms present in order of diminishing size are *m*(110), *o*(011), *c*(001), *l*(104), *d*(102), *z*(111), *y*(122), and U(201). In the macrodome zone the faces are curved, but otherwise the crystal is well developed.

This is the only barytes crystal that I have seen from the mines.

Celestine is listed among the secondary minerals by Sutton (*loc. cit.*, p. 3), but Wagner makes no reference to it. It has been obtained from the Wesselton Mine in small tabular fragments about 1½ cm. in diameter and 4 or 5 mm. thick. It is pale-blue in colour, and consists of silky fibres set perpendicular to the surface, so that the fragments appear to represent portions of a cross-fibre vein.

On crushing the material under a microscope, the fibres are seen to possess optically both positive and negative elongation, showing that the elongation is parallel to the β-vibration direction and the crystallographic Y axis. All the specimens examined were without any adhering country-rock, but it is probable that the veins are of secondary origin in the kimberlite.

Other more rounded fragments of celestine recovered from the pulsator-tables are granular or in radiating fibres, and rounded crystals up to 2 cm. in diameter are also common. They always possess a delicate bluish tint, and are sometimes associated with such secondary minerals as calcite and pectolite. Some such nodules obtained from the pulsator were analysed by Mr. John Parry, who obtained the following results :—

SrO	40·38
CaO	4·48
Na_2O	2·06
Al_2O_3, Fe_2O_3	3·40
SO_3	38·45
SiO_2	9·68
H_2O	1·00
	99·45

Quite recently Mr. A. F. Williams sent to me for identification a magnificent crystal of celestine from Bultfontein Mine at the 1120-foot level. It is pale blue in colour, and represents part of a huge crystal. It is somewhat tabular, parallel to the basal pinacoid, and measures $7 \times 6 \times 3$ cm. It shows the forms *m c o l*, the basal plane being modified by vicinal faces of a form about $\xi(0.1.12)$, and the front coigns modified by somewhat rounded faces of a form near (421), but the exact indices of these last two forms could not be determined with certainty owing to the fact that they gave multiple images. The crystal is broken at the base along the basal cleavage, and in places there are small isolated spheres, up to 2 mm. in diameter, of pectolite partially or completely enclosed by the crystal. This pectolite is very much altered, and itself encloses minute needles of natrolite. The crystal of celestine is thus a secondary mineral of relatively late formation.

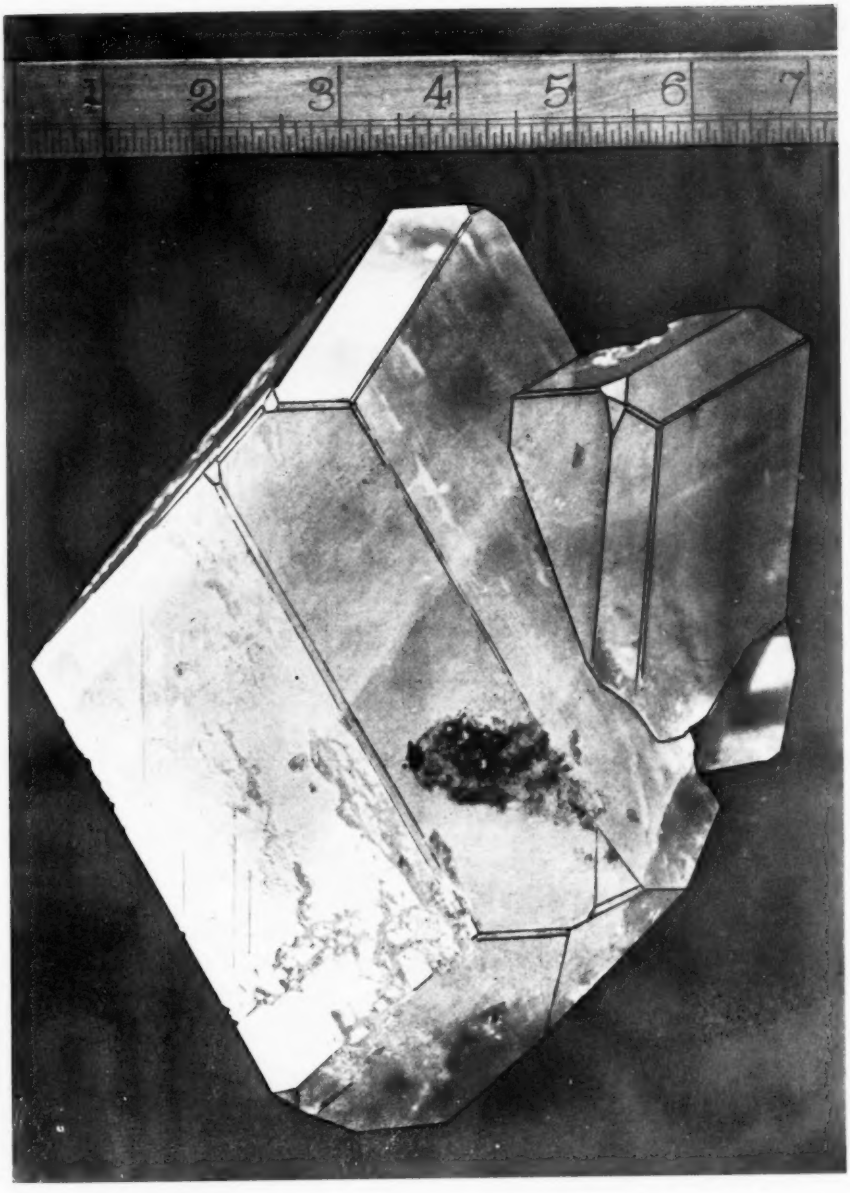
Some very fine specimens of *anhydrite* have been obtained recently from the Wesselton Mine. One such specimen was presented by Mr. A. F. Williams to the Albany Museum, and consists of pale-blue bladed crystals about a quarter of an inch wide and up to 3 inches in length arranged in subparallel position. The three mutually perpendicular cleavages are prominent but no crystal-faces are developed. The crystals are intimately associated with aggregates of somewhat flaky apophyllite crystals, which are disposed on a thin crust of greyish gyrolite. They occupy cavities and fissures in an elongated block of Karroo sandstone about a foot long.

So far anhydrite has been obtained only from the Wesselton Mine.

Gypsum is another sulphate of secondary origin found in the mines. One specimen (McG. Mus. 384) consists of a group of fine clear crystals up to 2 cm. across, showing the common habit $m(110)$, $l(111)$, and $b(010)$, and disposed on a light-red silicified banded shale. Many of the crystals are vertically striated on the prism and pinacoid faces. In other specimens this mineral occurs in a massive form.

Summary.

An enormous variety of minerals has been recorded from the kimberlite pipes, and some of them, especially the secondary minerals, show a wealth of crystal-forms. Minerals, previously not mentioned, are molybdenite, galena, chalcopyrite, aragonite, marcasite, orthoclase, pectolite, anhydrite, and gypsum. Unusual types of twinning in diamond, a variety of forms and habits in calcite, and a twin of apophyllite on $y(310)$ are described.



CALCITE FROM JAGERSFONTEIN MINE.
From photograph by A. M. Duggan-Cronin.

Neill & Co., Ltd.

THE BUSHMEN-HOTTENTOT-STRANDLOOPER TANGLE.

By T. F. Dreyer, Grey University College, Bloemfontein.

(With Plate II and four Text-figures.)

There is no more controversial subject in South African Anthropology than the relation between the Bushmen and the Hottentots.

Drennan (1) says : " Then there is the small group of short, yellowish-brown South African Bushmen and Hottentots, constituting the Bush Race."

Stow (2) considers the Bushmen to be the aborigines of South Africa, and the Hottentots as comparatively late immigrants from Central Africa, along the West Coast.

Péringuey (3) could not distinguish between present-day Bushmen and Hottentots, and considered the Strandloopers as ethnically older in South Africa.

Shrubsall (4) considered the Strandloopers as the purest race ; the up-country Bushmen intermediate between Strandloopers and Hottentots, and the latter intermediate between Bushmen and Bantu. In a later publication (5) he finds that he is quite unable to distinguish between Bushmen and Hottentots.

Broom (6) is of opinion that the term " Strandloopers " should never have been used ; that people who had been so called were Hottentots along the West Coast and Bushmen along the South Coast. He further suggests that the Bushmen are the degenerate (pygmy) descendants of the " Boskop man," and that of modern Bushmen the Karoo Bushmen were comparatively tall and robust and could be regarded as ancestral to the smaller northern forms. From amongst the Hottentots he picks out the Korana tribe as the ancestral Hottentot (frequently with Australoid brow ridges), and regards the Hottentots as very ancient inhabitants of South Africa.

Vedder (7) divides the Hottentots into Cape Hottentots, Korana, and Nama, and considers them as an Hamitic race that has had contacts with Arabs, Bantu, and Bushmen, and that speaks three dialects of a common language.

Spannaus (8) considers the Hottentots a southern group of Hamites ; he states that the Hamitic and Semitic languages are closely related ; that

the Hamite is, according to Reche, a subtype of the Mediterranean race; that both are modern representatives of the Cro-Magnon race, and that the domestic animals of the Hamites indicate a fairly late contact with Asia.

Lebzelter (9) finds that the Bushmen and the Hottentots belong to one big race; that the desert forms of the Kalihari and of the Namib are highly specialised, whilst the Northern (Jungle forms) are more primitive; that the desert forms combine European and Mongolian characters and are light coloured, whilst those of the "Kungveld" are darker and larger; and that the Bantu is an Hamitic race in which has been incorporated Bush, Hottentot, Jungle, Bantu, and Australoid elements.

Hirschberg (10) considers that the possession of fat-tailed sheep indicates a late arrival of the Hottentots in South Africa.

Bayer (11) divides the Hominidae into—

(*a*) hand-axe producing man, represented by Eoanthropus and Mongols (we must accordingly suppose South Africa's first inhabitants to have been of this type);

(*b*) broad-flake producing man, represented by Pithecanthropus, Sinanthropus, and Neanderthal man (also this group must have been present in South Africa);

(*c*) narrow-flake producing man—modern man.

Shapera (12), discussing the relationships of Bushmen and Hottentots, concludes that Hottentots are not Hamites influenced by Bushmen, but that they are Bushmen influenced by Hamites.

The various points at issue, still unsettled to-day, are :—

1. Is there a Strandlooper race (Péringuey and Shrubsall), or does the term merely connote a particular method of life adopted by Bushmen, Hottentots, etc. (Broom) ?

2. Is the Hamitic race represented in South Africa by the Hottentots (Spannaus and others) or by the Bantu (Lebzelter) ?

3. Is the Hottentot race a comparatively recent immigrant to South Africa (general opinion), or is Broom right in claiming them as old inhabitants of this area ?

4. How did the Bushmen originate ? From the taller, darker races of the North (Lebzelter) ? From the taller, undegenerate race of the South (Broom) ? By arrested development from a larger race (infantilism of Drennan) ? By crossing of the original pygmy race with some other ?

5. Do the Bushmen and Hottentots belong to one basal stock (Drennan, Lebzelter, and others), or are they from different sources (Spannaus and others) ?

If these were easy problems there would not be that amount of divergence of opinion which there is. They cannot be settled lightly, but the writer

believes that his collections of human material throw a little new light on some of these questions, and that this justifies a few remarks on them by him.

Strandloopers.

Broom's contention that Strandloopers are Bushmen-like and Hottentot-like (in 1921 Péringuey had come to the same conclusion) can be accepted as very largely correct. It is, however, not clear why Bushmen should have abandoned their own method of life in favour of becoming Strandloopers. That they did do so is clear from the succession in certain "kitchen middens"; for instance, at the mouth of the Great Brak River, near George, there is a very large midden, throughout the different layers of which there is the same type of stone implements and pottery; but the lowest layer consists almost wholly of bones of seals, various antelopes, and bush-pig, the second thin layer consists of fish scales and bones, whilst only the top layer is composed of the usual kitchen-midden material.

The pottery is of the type commonly ascribed to Bushmen. Shapera, who seems to have studied the literature thoroughly, says of this pottery (page 849): "The same kind of pottery has been found in Bushman deposits," and (page 846) "the manufacture of stone implements and clay pottery seems to have been confined to the southern tribes." He ascribes the absence of this culture amongst the northern tribes to contact with the iron-working Bantu, but the present writer sees difficulties in the way of accepting this view; viz., firstly, if the original Bushman containers were clay pots, how is it that the historically known Bushman used skins and ostrich egg-shells as containers? If they abandoned their own culture on coming into contact with the Bantu, we should expect them to adopt the Bantu clay pots instead. Secondly, the typical South Coast pots—ovoid with pointed base and made of coarse materials—are not, as Shapera states, confined to the south. The writer found, on the bank of the Riet River at Slagpaal, near Koffiefontein, O.F.S., a group of four graves which were unique in his experience. They were extremely shallow (about nine inches); there was no sign, in any of the four, of a vertebral column; all four were marked by a small group of four or five quite small stones; all four contained, besides the bones, a muller and grinder (red with ochre) each; one contained the base of a typical Strandlooper clay pot, and all the skeletons (very badly preserved although enclosed in a stiff clay) belonged to a tallish (5 ft. 4 in. to 5 ft. 6 in.) race with large skulls, big faces, and extremely thick cranial bones. These skeletons have not yet been described (only one skull is fairly complete; two are in fragments, which are so distorted that a reconstruction is impossible; and of the fourth, only a few pieces of the calvarium were found), but they can by no stretch

of the imagination be described as Bushmen. The lowness of the skulls, massive nature of the facial and cranial bones, the shape of the forehead, the prominence of the glabella, the width between the mastoid processes, and the shape of the auditory bones rather remind one of the Matjes River Man described by the writer (13).

Taking, therefore, into consideration the little that we do know about the matter, it is the opinion of the writer that the Bushmen, where they did make use of pottery, borrowed this culture. If this view is correct, then the Bushman-like Strandloopers are to be taken as a mixed race; as Bushmen who have come into contact with a pottery-making coastal race.

This view is apparently in conflict with Shrubsall's statement that the Strandloopers are the purest ethnic group of all those submitted to him. Broom has, however, already pointed out that the skulls were grouped so as to include under Strandloopers both Bushmen and Hottentots; and the writer has five skulls from shell deposits in caves at Klein Brak (Mossel Bay), which shows a third element—that element which Dart and his assistants have called the South-east Coast Boskopoid. One of these skulls is very large (cranial capacity, 1570), with massive cranial bones, and gives a craniogram very similar to Dart's larger skull from Knysna.

Further, the Matjes River Man gives us a fourth element—antecedent to the occupation of the Matjes River Cave by a smaller Bushman-like race, mixed with the Matjes River race.

Shrubsall's statement, then, that the Strandloopers represent a pure race cannot be accepted, and the indications are that at least two races lived along the South Coast before the Bushmen mixed with and supplanted them—one with the Mongolian broad head, full, high forehead, and flat face; the other with those Australoid characters which the writer has pointed out as characteristic of Matjes River Man.

It may be pointed out that this contact and mixture of successive waves of immigrants at the South Coast is just what one would expect to find, judging by our knowledge of the distribution of animals.

The Bushmen.

Broom claims that he is able to distinguish Hottentot and Bushmen skulls quite readily. Now if one has somehow or other established some sort of a criterion as to which skulls should be called Bush and which Hottentot, it would no doubt be easy. What I mean to say is, that once personal selection has grouped the available skulls, distinguishing characters could be found; and to point this contention, I need only state that (*a*) the skull which Broom groups under Korana Skulls with the label,

"Very Old Grave, Bucklands," is, from what I was told in Douglas, one found by a Greek at Bloubosdrift (opposite to Bucklands Island), and sold to Broom. It is stated that this skull was from a shallow grave, marked by one flat stone, with the skeleton in a sitting position. This type of grave is typical of Bushmen, and it seems to me that to group it under Hottentots (Korana) is merely acting on preconceived ideas; (*b*) the skull, labelled "Present-day pure Korana, Kenhardt," and included under Korana Skulls, is without a doubt one obtained by Broom on the farm of Mr. Boy Cilliers—the history of which is quite unknown and which can therefore only be grouped as "Pure Korana" on preconceived notions.

As far as actual measurements are concerned, Broom relies on the height and the height-breadth index as the main criterion for distinguishing Bushmen from Hottentots. Now the present writer does not wish to deny that the skulls of Southern Bushmen (in which Broom includes the very broad-headed Strandloopers) are low (like Hottentots), and very broad (unlike Broom's conception of the Hottentot skull). This may well be so as an average relationship, but three points must here be accentuated :—

(*a*) Is the breadth measured, as Drennan puts it, "distance between the two widest points of the skull," or as Rauber-Kopsch (Lehrbuch der Anatomie) prescribes : "Die grösste Breite des Hirnshädels oberhalb des Porus acusticus ext. und an der Sutura squamosa." The difference in taking these two measurements for the very broad Strandlooper skulls may be as much as 12 mm. The height is not very important—both Bush and Hottentot skulls are low ; it is the breadth that matters, and this depends very much on the manner of taking it.

(*b*) According to Baur, Fischer, and Lenz (Menschliche Erblichkeitslehre) an increase of stature, which may be due to the environment, goes hand in hand with increased length of cranium (and also decreased cephalic index). Thus to say that great breadth (of short-headed small Bushmen) is characteristic of Bushmen, since even very long-headed skulls of other races have little or no greater breadth, is not a very convincing argument in favour of the ethnic distinctness of the Bush race.

(*c*) Although we should concede that Bushmen have a lower height-breadth index than Hottentots, yet this can only be conceded as an average difference, and individuals may very well not show this distinction. Take for instance No. 26 of Shrubsall (Bushman) and compare it with Broom's "Pure Korana, Kenhardt." The respective measurements are : length 183, 185 ; breadth 127, 131 ; height 124, 125 ; height-breadth index 97·6, 95·4—that is, Shrubsall's Bushman is slightly *less* Bushman-like than Broom's Korana.

What Broom really seems to use as a distinction is: (*a*) the prominence of the parietal eminences, (*b*) the flatness of the posterior portion of the parietal, and (*c*) the relative shortness of the occiput in Bush skulls.

The first two characters—prominent parietal bosses and flatness of the area in between—seem to be related, and Broom states that "in the Kalihari Bushmen the parietal depression, though present, is less marked." Now this breadth of the skull (due to the parietal bosses) is most marked in the South Coast Strandloopers, whom the writer has referred to as Dart's South Coast Boskopoid—an element foreign to the real pygmy Bushman. The writer has two very ancient-looking skulls of pygmy Bushmen; one is from a shallow grave (the single burial stone was covered by a foot of soil, and the bones are well fossilised) from the neighbourhood of Douglas. In this skull the region concerned is well rounded. The other is a calvarium (the associated humerus and two tibiae show it to have belonged to a very small individual $\pm$ 4 feet) which was washed out of the banks of the Kaffir River; this calvarium is very interesting in its massive bones and its flatness, and also has the parietal region well rounded. The writer is therefore of opinion that these characters—prominent bosses and flatness of the parietal—are not original Bush characters, *i.e.* of the pygmy race.

Here Broom's theory as to the origin of the pygmy race by degeneration from a tallish, robust Karroo race must be referred to. One is so accustomed to supposing that the pygmy Bushmen of the south must be related to the various other pygmy races, that such a view—that the South African pygmies originated in South Africa, and that they are to-day separated from the central African pygmies by a region for which it is commonly accepted that the farther north one goes the more impure the race becomes—seems utterly surprising. The writer has personally attempted to obtain specimens of Broom's undegenerate Karroo Bushmen, and has succeeded in obtaining a complete skeleton of an individual very similar to those that Broom describes. He does not say anything about the state of preservation (his figure indicates that this was good) or about the method of burial. The skeleton that the writer obtained was beautifully preserved and is quite recent looking; it was buried lying on its side with legs pulled up (sleeping position) in a shallow grave ($\pm$ 2 feet) with long pillar-like stones piled on it in a radial arrangement. Before it was disturbed it had a conical form ($\pm$ 3 feet high) with outer stones standing nearly upright. With the skeleton (under the sacrum) was found a peculiar polished ring—apparently cut out of a flat plate of bone. The posterior end of the maximum length line is (as in Broom's fig.) farther removed from the Frankfort plane than it is in Bush skulls, and the writer regards it as Hottentot. That this recent-looking skeleton cannot be regarded as the ancestral form of the pygmy bushman is shown by the occurrence in the same region (Murrays-

burg) of the ancient-looking remains of real pygmies (the writer obtained various bones—not the skull—of an individual, who could not have been over 4 feet in height, from the bank of a spruit on the farm Toorfontein near Murraysburg).

In fig. 1 the median craniograms of those skulls in the writer's possession,

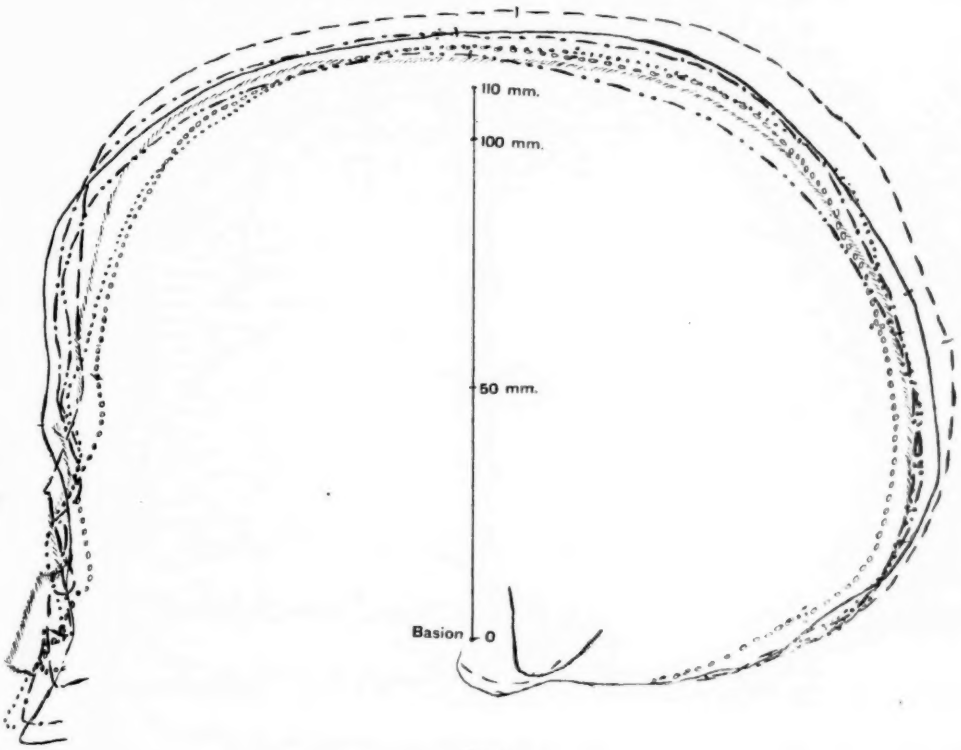


FIG. 1.

which belonged to very small individuals, have been superimposed. After numerous trials it was found that the most suitable plane on which to orientate them is the plane of the foramen magnum (in most skulls this coincides more or less with the Frankfort plane).

They agree very well in general, but the following points may be observed :—

1. In the two oldest skulls (a fossilised skull—*even black line*—from a 18-inch burial under a large flat stone, the latter about 1 foot under the

surface of the ground, near Douglas ; and an old-looking skull washed out of the bank of the Kaffir River, associated with bones showing that the stature was ± 4 feet, indicated by — · · —) the glabella lies nearer the plane of the foramen magnum than in the other more recent skulls ; the face is " less open " as Keith * puts it.

2. The above-mentioned Kaffir River skull is very low and has a remarkably uncurved parietal (*i.e.* along the median line ; transversely it is very much curved).

3. The —— · —— · —— line represents a skull of a very small Bushman of known history from Bloemfontein district ; it has the parietal bosses and parietal flattening which Broom finds characteristic of Bushmen,

4. The ''''''''''''' line represents a remarkably flat skull (female ?). with Australoid form of palate, from Klein Brak River. Parietal region well rounded.

5. The interrupted line (—— —— ——) represents an extremely aged female (fairly recent ; glass beads found in the grave, which was of Griqua type with the body in a side excavation of the grave, the latter being filled with stones and soil). She was of fairly low stature, and the skull has the parietal bosses and flattening mentioned above, but the curvature in the posterior part of the skull resembles that of the Hottentots, and she was probably of mixed blood. Locality, Douglas.

6. The dotted line represents a skull of a small, old male, buried as in 5, at Afvallingskop, Fauresmith. The °°°°°° line represents a skull from a similar type of grave near Douglas ; both these skulls, although belonging to small individuals, show admixture with Hottentot—an admixture which is particularly evident in the slope of the forehead and the straight (not incurved) line of the whole face.

If we now turn to fig. 2, which represents four skulls from a cave near Great Brak River, George ; two skulls from the Matjes River Cave (in the lower layer of which the Matjes River race described by the writer was found), and one skull, viz. the above-mentioned recent Bushman from Bloemfontein, it will be seen that—

(1) the foreheads are more vertical than in the inland Bushmen ;

(2) the faces are more curved inwards (they are also flatter in front view) ;

(3) the skulls tend to be larger—they belong to bigger individuals too —and the inion area is exceedingly prominent, so that the whole hinder part of the head appears to be flattened in median section ;

(4) the foreheads of the two skulls from the Matjes River Cave (— — — and — ı — ı —) are more prominent than in the others. When we then note that this is a strongly marked feature of the Matjes River race—the origin of this character, in these otherwise Bushmen-like individuals, seems

* Keith, Antiquity of Man.

obvious. The extreme prominence of the inion area is, however, not characteristic of the Matjes River race, and it is also not sharply marked in the Matjes River Cave Bushmen. It is not a feature of any known South African race, and we must, as previously stated, postulate a

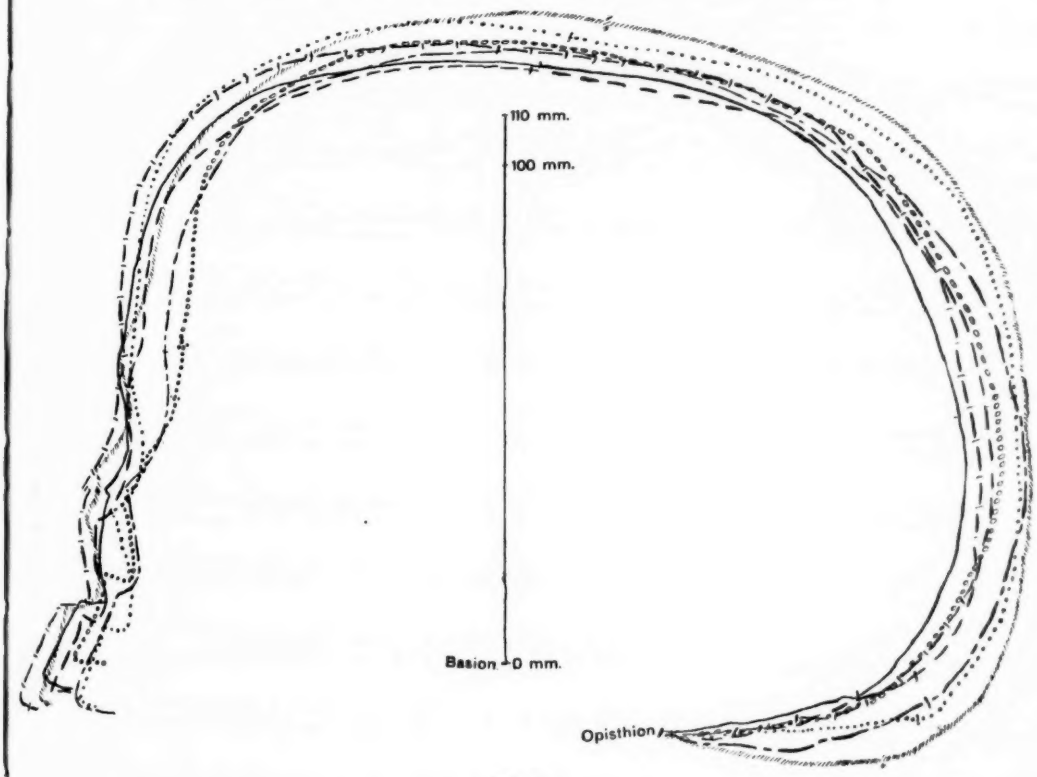


FIG. 2.

second pre-Bushman race (with large broad heads and flat faces) to account for this peculiarity (represented by the skulls from Great Brak River).

Fig. 3 shows craniograms of a Hottentot from Groot Brak (in kitchen midden)—continuous line; one from Oudtshoorn—dots and dashes; one from Beaufort West—interrupted line (this is the one already mentioned as similar to Broom's ancestral Bushman); and one from Koffiefontein —dotted line. They are all very similar, except that the one from Beaufort

West has prominent parietal bosses, whilst the Koffiefontein skull has a very narrow face. (It shows distinct resemblances to Elementeita man.)

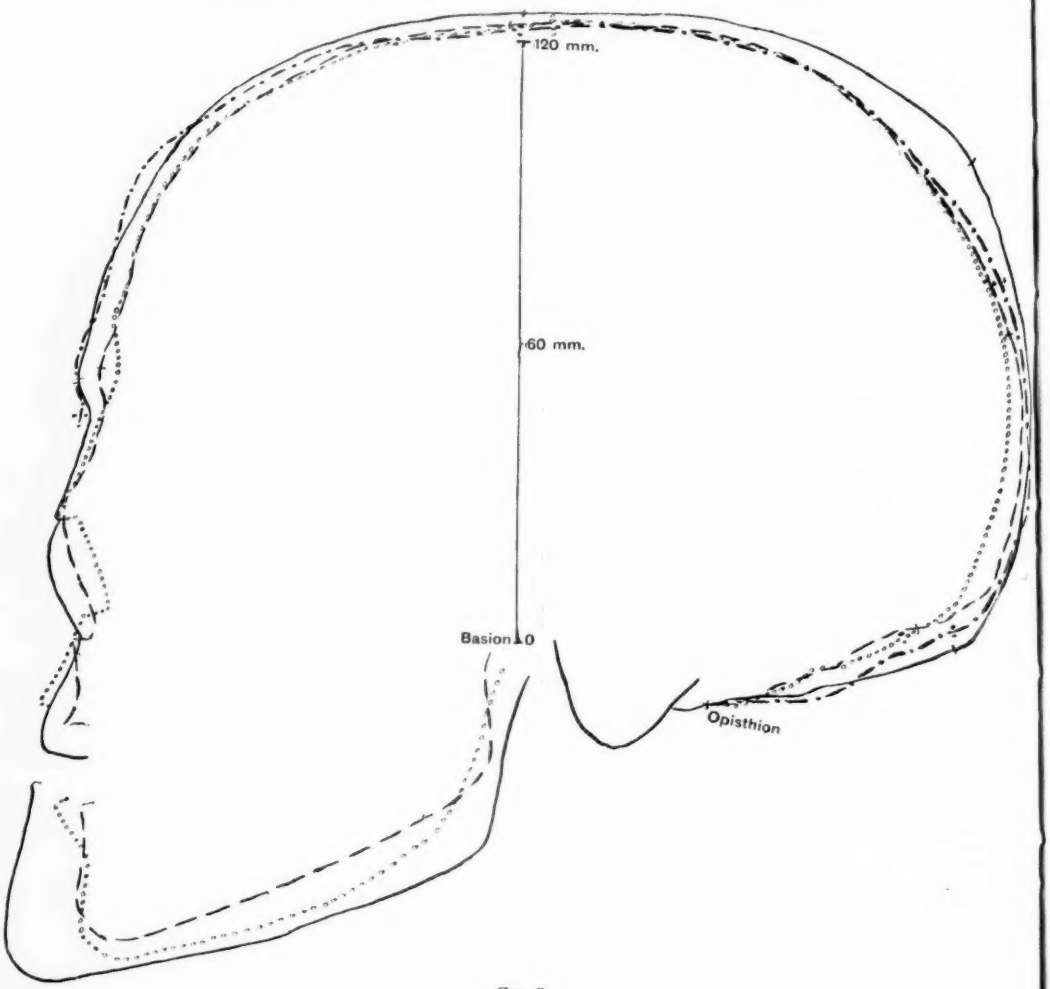


FIG. 3.

The slope of the forehead and of the face—with fairly prominent noses, or, as Broom puts it, the almost Grecian profile (except that the Greeks over-accentuated the straightness of the forehead), and the long occiput,

which Broom also mentions as characteristic of this race, together with the comparatively low basi-bregma height, seems to the writer to distinguish the older Hottentots very sharply from the Bushmen, and to place them near that race which Keith calls the River-bed man or Mediterranean race—a position which one would expect if one accepts their language as akin to Hamitic.

The orbits of the skulls from Groot Brak River and from Oudtshoorn are low and long, as in the Matjes River race and in the Cro-Magnon race —of which the Hottentots, if they are Hamites, are modern representatives.

It is further interesting to observe that the femur of the Oudtshoorn skeleton shows that dorso-ventral flattening at its upper end, and the tibia the lateral flattening which Sir Arthur Keith lays stress on as characteristic of his River-bed Man.

If now the Hottentots are Hamitic descendants of the Cro-Magnon race and the Matjes River race is somewhat similar to the original Boskop skull, which Haughton places near the Cro-Magnon, what then is the relationship of the Hottentots to the Matjes River race ?

In fig. 4 there is a comparison between these as far as the median craniograms are concerned. There are, of course, very many points of difference not shown by this method, the most obvious of which are seen in norma verticalis and norma occipitalis (narrow forehead combined with large parietal bosses and lack of curvature of parietal as seen in norma occipitalis), but the figure also shows that the Hottentot (the continuous line represents the skull from Klein Brak River—the one which approximates most closely to the Matjes River race in the nature of the median craniogram) has a lower head, a more sloping forehead, a less full cerebellar region, and is much less prognathic. The Matjes River skulls used are MR2 (interrupted line), and MR3 (dotted line). The line of dots and dashes represents a restored skull from the sand-dunes near Gordon's Bay, which has some characteristics of the Matjes River race (thick cranial bones, narrow forehead, great width at the region of the parietal bosses, and flatness of the parietal as seen in norma occipitalis) in an accentuated form. The craniogram shows it to be very prognathic ; but if the position of the malar of MR2 be noticed, and one bears in mind the very pronounced subnasal prognathism of many MR upper jaws, it will be evident that MR2, if restored, would be even more prognathic. The Gordon's Bay skull is illustrated by photographs on Plate II.

This extreme prognathism with the guttered noses are characters which are often spoken of as negroid features, but may just as well be regarded as characteristic of primitive man—as features which some races have retained and others not.

Taking everything into consideration, it seems to the writer that we

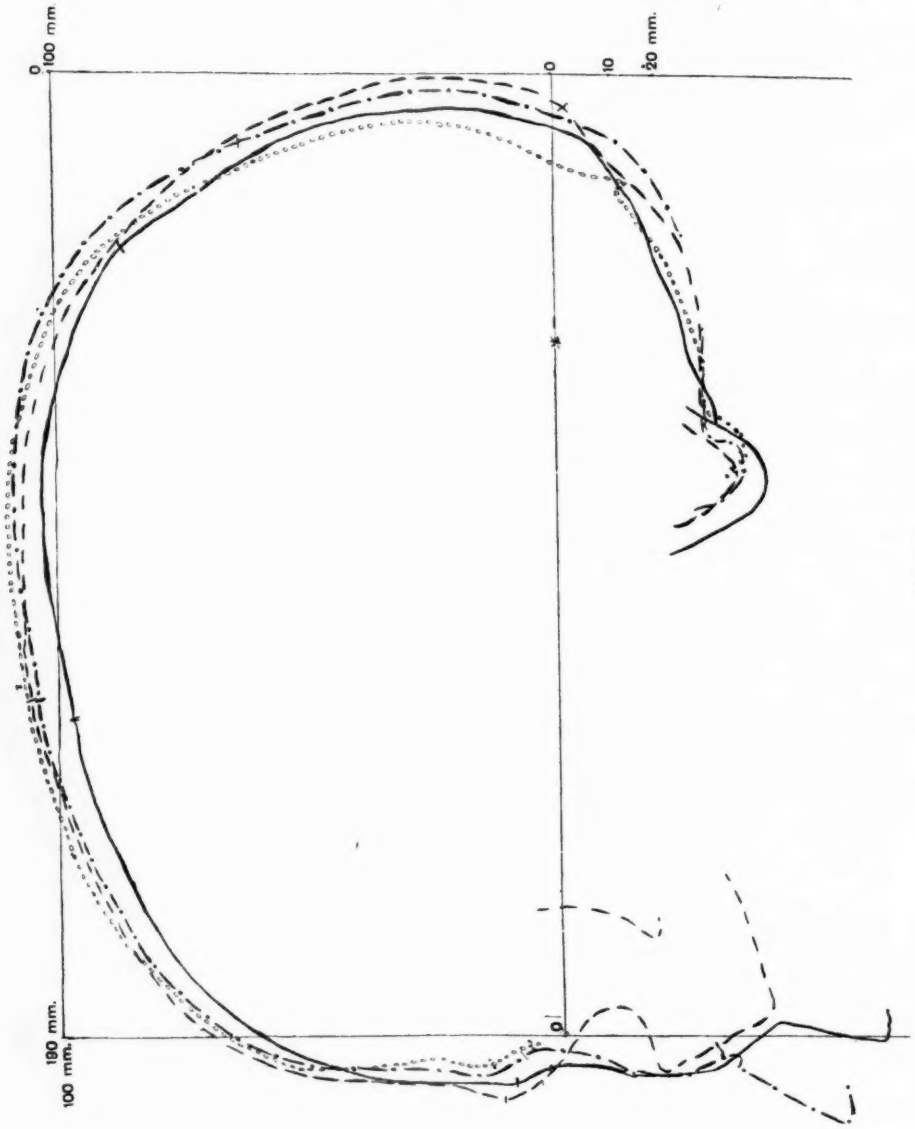


FIG. 4.

can consider the Matjes River race as an ancient Cro-Magnon-like race (using the Mossel Bay type of stone implements), whilst the Hottentots are recent immigrants of the more modern Mediterranean race, possibly with some other admixture.

LITERATURE CITED.

1. Drennan.—A Short Course of Physical Anthropology.
2. Stow.—The Native Races of South Africa.
3. Péringuey.—As quoted by Broom.
4. Shrubsall.—Ann. of the S.A. Mus., vol. v, 1907.
5. Shrubsall.—Ann. of the S.A. Mus., vol. viii, 1911.
6. Broom.—Royal Anthrop. Inst. of Great Britain and Ireland, vol. liii, 1923.
7. Vedder.—Journ. of the S.-W. Afr. Sci. Soc., vol. i, 1925–26.
8. Spannaus.—Zum Hamiten Problem in Forschungen und Fortschritte der Wissenschaft, Jan. 20, 1931.
9. Lebzelter.—Forsch. u. Fortschritte, Feb. 1, 1929.
10. Hirschberg.—Forsch. u. Fortschritte, May 1, 1931.
11. Bayer.—Forsch. u. Fortschritte, March 20, 1931.
12. Shapera.—South Afr. Assoc. for Adv. of Sci., Dec. 1926.
13. Dreyer.—Dreyer and Lyle: Fossil Mammals and Man from South Africa. Published by Dept. of Zool., Grey University College, Bloemfontein.

EXPLANATION OF FIGURES.

Fig. 1.—Median craniograms of skulls of dwarf individuals in the Grey University Collection.

a ———————— : A calcified skull from Rooikoppies, Douglas (Bush type of burial); ♂.

b — — — : A skull of very old ♀ from C. de Villiers, Douglas; Griqua type of grave with glass beads; probably of mixed race.

c — · — · : Old Bushman ♂ (history known) from Bloemfontein district.

d — · · — · · : Calvarium (♀?) washed from bank of Kaffir River, near Bloemfontein. Donor, R. Holmes, Esq.

e ////////////////////: Skull from a small cave near Klein Brak River. Donor, Mr. C. Robertson.

f ..... : Small ♂ with neck vertebrae absent and base of skull injured by sharp instrument, from Afvallingskop, Koffiefontein, O.F.S. Burial as in case of *b*.

g °°°°°°°°°°°°°°°°°° : Skull buried as in case of *b* and *f*, but with string of ostrich egg-shell beads. Bank of Orange River, below Douglas.

Fig. 2.—Median craniograms of Strandloopers from two South Coast shelters compared with Northern Bushman.

a ———————— : Same skull as figured in Fig. 1, *c*.

b — | — | — } Two skulls from the upper layer of the Matjes River Cave, from
c — — — } the deeper layers of which the Matjes River race was obtained.

d ////////////////////: A narrow skull of a tall man from a shelter on the farm of Mr. Groenewald, near Groot Brak River, Mossel Bay.

e ..... : } Three broad skulls with broad, flat upper faces and pointed
f — – — – } chins, from a shelter on farm of Mr. Groenewald, Groot
g °°°°°°°°°°°°°°°°°° } Brak River. Dug up by owner of farm before farm visited by writer. No deposits undisturbed, so association with implements could not be determined.

Fig. 4.

FIG. 3.—Median craniograms of tall individuals with large, long heads: Hottentots.

a ————————: Dug up from sand-dune at Hartenbosch, Mossel Bay, by Mr. George Robertson, Klein Brak River. From information received from Mr. Jacob Smit, teacher, Oudtshoorn, the skeletal remains were associated with a complete Strandlooper pot—now in Mr. Smit's possession.

b —— · —— · : Injured skull dug up by children near the Cango Caves, Oudtshoorn; rescued and presented by Mr. Pocock, attorney, Oudtshoorn. Mr. Pocock states it was from a very shallow, round grave.

c —— —— ——: From round conical graves near farm of Mr. James Oosthuizen, between Klaarstroom and Beaufort West.

d °°°°°°°°°°°°°°°°°: From square, shallow grave near Koffiefontein. Ostrich eggshell beads; cowry and conus shells; ring of brass (?) wire.

FIG. 4.—Median craniograms of three Matjes River race skulls compared with a Hottentot skull.

a ————————: Same as Fig. 3, *a*.

b —— —— ——: MR2. Similar to the original Boskop calvarium.

c °°°°°°°°°°°°°°°°°: MR3.

d —— · —— · : Restored skull from sand-dune, Somerset West. Presented by Prof. A. Francken.

PLATE II.—Photographs of the skull represented by fig. 4, *d*.

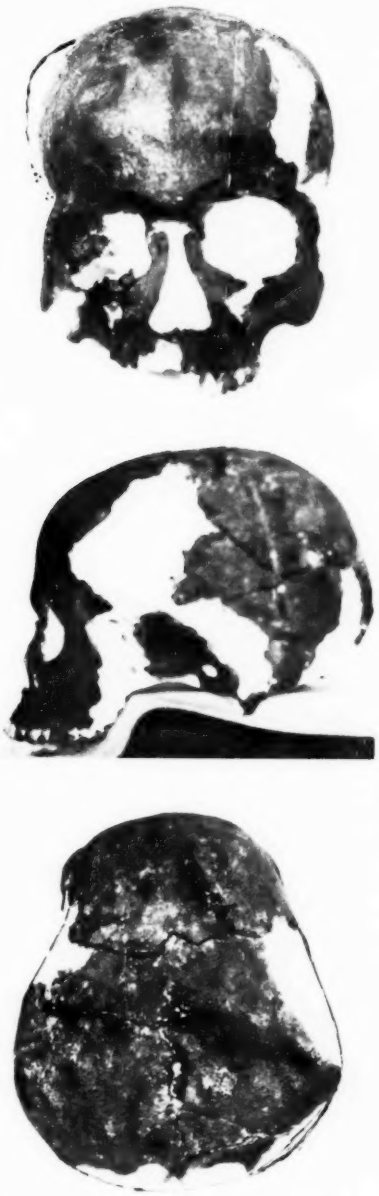


FIG. 5.—Photographs of the skull from Gordon's Bay, which is represented in Fig. 4 by a continuous black line.

Neill & Co., Ltd.

THE INFLUENCE OF FLUORIDES ON THE REDUCTION OF POTASSIUM PERMANGANATE.

Part I.—Reduction with Antimonious Salts.

By W. Pugh.

The most common method employed in practice for the estimation of antimony in white metals is the method of Tereshchenko. This consists in decomposing the alloy with concentrated sulphuric acid and titrating the antimonious salt produced with standard potassium permanganate. The antimony is oxidised according to the equation—

$$4MnO_4^1 + 5Sb_2O_3 + 12H^+ \longrightarrow 4Mn^{++} + 5Sb_2O_5 + 6H_2O.$$

In order, however, that oxidation may proceed uniformly and completely according to this equation it is essential to add hydrochloric acid before the titration, and it is generally assumed, after Kessler (1), that the solution must contain about one-sixth part by volume of concentrated hydrochloric acid. Some yet unpublished work by the author, however, indicates that such high concentrations are unnecessary. A consequence of such high concentrations of hydrochloric acid is the fleeting nature of the end point, and especially so if the solution be not well cooled before titration. This same difficulty of the fading of the end point is even more pronounced in the estimation of iron in the presence of hydrochloric acid, but it is overcome in this case by the well-known method of Zimmermann and Rheinhard. The author therefore made various attempts to apply this method to the case of antimony, but without success. In most of the titrations the end point was even more fleeting.

Another method of overcoming the difficulty in the case of iron is to add potassium fluoride (2). This seemed to be the ideal material to counter the influence of hydrochloric acid in the estimation of antimony, because antimony trifluoride is not decomposed by water, thus making the use of hydrochloric acid unnecessary.

The literature on the reduction of permanganate is very voluminous. It is well established that reduction proceeds in stages and that the products may be tetravalent, trivalent, or bivalent manganese. The extent to which reduction occurs depends on a number of factors, such as the concentration of the hydrogen ion in the solution, the nature of the reducing

agent, and the nature of the foreign ions in solution. Skrabal (3) and Skrabal and Preiss (4) state that the mechanism of the reduction is independent of the nature of the reducing agent, and that reduction in acid solution proceeds through the intermediate formation of manganic ion. They show that in the oxidation of oxalic and formic acids by potassium permanganate there is an incubation period during which there is a slow reduction of the permanganate to manganic ion. The rate of this reaction is measurable. This incubation period disappears on the addition of manganous salts, when interaction proceeds according to the equation—

$$4Mn^{++} + MnO_4{}^1 + 8H^+ \longrightarrow 5Mn^{+++} + 4H_2O.$$

They show that it is the manganic ion produced in this way which is the active agent in oxidising oxalic and formic acids. Further observations on this subject are made by Holluta (5 and 6).

The view that the mechanism of the reduction is independent of the nature of the reducing agent does not seem to agree with some other facts of more recent date. The results of the author on the reduction of permanganate with antimony salts, quoted herein, and of others on the reduction with arsenious acid show that reduction may be arrested completely at the stage corresponding to trivalent manganese. In these cases it cannot be manganic ion which brings about oxidation; and since there is no detectable incubation period, as in the case of oxalic acid, it is probable that the reaction is one of direct oxidation by permanganate ion.

The reduction of permanganate by arsenious acid has been particularly well studied on account of its use in the Proctor Smith (silver nitrate-persulphate) method for the estimation of manganese in steel. Here again it has been shown by Kropf (7) that reduction to bivalent manganese is only possible in the presence of hydrochloric acid. In the presence of other acids, reduction to various intermediate stages takes place. Thus, when potassium permanganate is titrated in 2·5*N* sulphuric acid with sodium arsenite, the manganese is reduced to an average valence of 3·3, while, if the titration be reversed, the manganese is reduced to an average valence of 2·5. These figures are given by Hall and Carlson (8), who also give a good bibliography on the subject. More recent work has been carried out by Oryng (9) and Holluta (10).

The influence of fluorides on the reduction of permanganate appears to have been first noticed by Peters (11), who, however, made no measurements on the subject. Müller and Koppe (12) studied the oxidation of manganous salts by permanganate, and found that in the presence of fluorides the whole of the manganese is oxidised or reduced to the trivalent state, according to the equation—

$$MnO_4{}^1 + 4Mn^{++} + 8H^+ \longrightarrow 5Mn^{+++} + 4H_2O.$$

They were able to isolate from these solutions some complex fluorides, of the type $2KF . MnF_3 . H_2O$. Metzger and Marrs (13 and 14) and Holluta and Obrist (15) have confirmed this, and they have proposed the reaction as a basis for the estimation of manganese.

The influence of fluorides on the reduction of permanganate by arsenious acid (with reference to the determination of manganese in steel) has been studied by Travers (16) and Swoboda (17). The latter has shown that fluorides are far more consistent than other materials suggested in their effect in stabilising trivalent manganese. The reaction is almost quantitative according to the equation—

$$4MnO_4^1 + 4As_2O_3 + 16H^+ \longrightarrow 4Mn^{+++} + 4As_2O_5 + 8H_2O.$$

So far as the author can ascertain, this appears to be a complete summary of the work done on this subject. It is generally assumed (Fales, Inorganic Quantitative Analysis, p. 300; and Hillebrand and Lundell, Applied Inorganic Analysis, 1929, p. 775) that the fluoride functions through forming stable complexes with manganic ion. The results of Müller and Koppe (12) certainly suggest this view, and there is some support for it in the work of Peters (11) on the influence of fluorides in decreasing the oxidation potentials of ferric salts.

It seemed desirable, however, to examine the subject more fully, because it is probable that fluorides will influence the degree of reduction of permanganate by other reducing agents, like oxalic acid, hydriodic acid, etc. That this is the case with antimony is shown in this communication.

Experimental Part.

Solutions required.—(1) Decinormal potassium permanganate, standardised, immediately before use with pure sodium oxalate; (2) antimony solution, prepared from pure antimony trioxide. The strength of the solution was determined by direct titration against the potassium permanganate in the presence of 20 per cent. by volume of hydrochloric acid, and it was checked against potassium bromate. Two solutions were employed: Solution A was made by dissolving approximately six grams of antimony oxide in 400 c.c. of 5N hydrochloric acid and diluting to 1 litre; solution B was made by dissolving approximately six grams of the same oxide in 180 c.c. of 10 per cent. potassium bifluoride and diluting to 1 litre. This latter method was a convenient way of getting a solution free from hydrochloric acid.

A few preliminary titrations had shown that the amount of permanganate consumed by the antimony solution was increased by 25 per cent. when an alkali fluoride was added before the titration. More detailed results are shown in Tables I–V.

Table I contains the results obtained with solution B, using different quantities of fluoride and sulphuric acid. 20 c.c. of antimony solution were used in each case.

TABLE I.—*Antimony Solution B:* 0·08100*N versus Potassium Permanganate* 0·09817*N*.

Total vol. c.c.	C.c. 6N H_2SO_4 present.	Grams KF . HF.	C.c. $KMnO_4$.	Valence of Mn in reduced state.	Remarks.
100	0	0·36	..	..	Brown precipitate formed.
100	2	0·36	20·65	3·005	Solutions became slightly orange in colour long before the end point, and brown precipitates formed on standing.
100	5	0·36	20·70	3·014	
100	10	0·36	20·65	3·005	
100	20	0·36	20·80	3·034	
100	20	1·36	20·75	3·025	
100	20	5·36	20·60	2·995	Solutions yellowish, end point very sharp.
200	20	5·36	20·65	3·005	
100	40	0·36	20·80	3·034	Solution decidedly orange.
100	40	5·36	20·70	3·014	Solutions almost colourless, end points very sharp.
200	40	5·36	20·70	3·014	
200	40	10·36	20·65	3·005	
100	80	1·36	20·90	3·051	Solution decidedly orange.
100	80	5·36	20·85	3·044	Colour almost disappears with increasing amounts of fluoride.
100	80	10·36	20·75	3·025	
200	80	20·36	20·70	3·014	
200	80	10·36	20·75	3·025	
	Conc. H_2SO_4 c.c.				
100	20	0·36	..	..	Orange colour too intense to distinguish the end point.
100	30	1·36	..	..	

Theoretical titre for reduction to Mn^{+++} = 20·6 c.c.

It is evident that reduction proceeds, under these conditions, to trivalent manganese. The permanganate titre, however, is consistently high, but this is possibly due to a delay in the appearance of the pink colour on account of the yellowish colour of the solutions. It will be noticed that the colour becomes more intense as the acid concentration rises. The titre also rises slightly. Increasing the fluoride concentration, however, counters both effects. With 5 grams of potassium bifluoride all solutions up to 5N sulphuric acid concentration were colourless, or slightly yellow

by reflected light. Dilution does not seem to affect the result. The important factor appears to be the ratio of acid to fluoride.

Table II shows the results with solution A, using hydrochloric acid. 20 c.c. of antimony solution were used in each case in a total volume of 100 c.c.

TABLE II.—*Antimony Solution A:* 0·08102*N versus Potassium Permanganate*, 0·09817*N*.

C.c. 5*N* HCl present.	Grams KF . HF.	C.c. $KMnO_4$.	Valence of Mn in reduced state.	Remarks.
18	0·0	16·40	1·97	Insufficient hydrochloric acid used.
28	0·0	16·50	2·000	
38	0·0	16·50	2·000	
8*	0·0	16·47	1·995	HCl concentration required diminished in presence of sulphuric acid.
13*	0·0	16·50	2·000	
3	0·5	20·60	2·994	Solutions clear throughout but developed an orange tint by transmitted light; gave brown precipitates on standing. End points sharp.
5	0·5	20·60	2·994	
8	0·5	20·40	2·954	
13	0·5	19·9	2·85	
18	0·5	18·2	2·47	
28	0·5	16·80	2·08	
8	2·0	20·68	3·010	
18	3·0	20·70	3·014	
18	5·0	20·75	3·024	All solutions developed a yellow to orange colour, but the end point was perfectly sharp.
28	3·0	19·5	2·77	
28	5·0	20·75	3·024	
28	10·0	20·80	3·033	

Theoretical titre for reduction to $Mn^{+++} = 20·62$ c.c.

* 40 c.c. of 6*N* H_2SO_4 also added.

These show the same general trend for reduction to trivalent manganese in the presence of fluorides. With hydrochloric acid, however, there is a greater tendency for more complete reduction. This tendency is absent with even high concentrations of sulphuric acid and nitric acid, while moderately low concentrations of hydrochloric acid are able to counteract the influence of the fluoride.

Table III. shows the results obtained in the presence of nitric acid and acetic acid, and of mixtures of sulphuric and hydrochloric acids. In

TABLE III.—*Antimony Solution B: 0·08100N versus Potassium Permanganate, 0·09817N.*

C.c. 5N H_2SO_4.	C.c. 5N HCl.	C.c. 6N HNO_3.	C.c. 2N acetic acid.	Grams KF . HF.	C.c. $KMnO_4$.	Valence of Mn in reduced state.
30	0	..	..	0·36	20·80	3·033
20	5	..	..	1·36	20·55	2·984
20	10	..	..	0·36	17·85	2·38
20	10	..	..	1·36	20·4	2·954
20	10	..	..	5·36	20·55	2·984
20	20	..	..	5·36	20·60	2·994
32	18	..	..	5·36	20·60	2·994
		4	..	0·36	20·70	3·014
		8	..	0·36	20·75	3·024
		16	..	0·36	20·75	3·024
		24	..	0·36	20·75	3·024
		32	..	0·36	20·70	3·014
		50	..	0·36	20·75	3·024
		80	..	0·36	20·80	3·033
			10	0·36	21·0	3·07
			25	0·36	21·75	3·165
			50	0·36	22·5	3·42

the latter case, it will be observed that the products are mixtures of trivalent and tetravalent manganese. Brown precipitates were formed on standing a few minutes.

A few titrations were made on solutions made from Kahlbaum's antimony dissolved in concentrated sulphuric acid. 0·1000 gram of antimony was dissolved in the quantity of sulphuric acid shown in Table IV. The solution was then diluted to 50 c.c. and boiled for five minutes to expel sulphur dioxide. Without cooling, the solution was further diluted to 200 c.c., treated with potassium bifluoride, and titrated with potassium permanganate. The end points were in all cases sharp. The results are consistent enough to justify the method for the rapid estimation of antimony.

Finally, a few titrations were made in the reverse way, titrating permanganate with a solution of antimony oxide in hydrochloric acid. The method, however, did not give good results. The colour change from pink to colourless, or faint orange in the presence of fluorides, is much more difficult to detect. All the solutions were in fact much more highly coloured when the titration was carried out in this way. Even in the absence of fluorides, orange-brown solutions were obtained when the hydrochloric acid concentration was low. A slight smell of chlorine was also

TABLE IV.

Conc. H_2SO_4 used for solution.		Grams KF . HF.	C.c. $KMnO_4$.	Valence of Mn in reduced state.
15		10·0	21·14	3·033
15		5·0	21·14	3·033
10		5·0	21·15	3·034
10		3·0	21·12	3·030
10		1·0	21·15	3·034
5		0·5	21·05	3·02
5		1·0	21·15	3·034
5		2·0	21·20	3·04
	C.c. Conc. HCl.			
15*	5	0·0	20·95	2·008
15*	10	0·0	20·97	2·01
15*	15	0·0	20·97	2·01

* 0·1250 gram of antimony was used in these cases.

TABLE V.—*Potassium Permanganate, 0·09323N versus Antimony Chloride, 0·08175N.*

C.c. 5N HCl.	C.c. 5N H_2SO_4.	C.c. 5N HNO_3.	Grams KF . HF.	C.c. $SbCl_3$.	Valence of Mn in reduced state.	Remarks.
9	..	..	0·0	21·5	2·286	End points difficult to detect and odour of chlorine.
14	..	..	0·0	21·5	2·286	
24	..	..	0·0	22·1	2·15	
44	..	..	0·0	22·0	2·17	
8	..	..	2·0	18·2	3·009	
8	..	..	5·0	18·23	3·003	
18	..	..	5·0	18·08	3·053	
28	..	..	5·0	18·25	3·000	
8	7	..	5·0	18·25	3·000	
8	14	..	5·0	18·15	3·02	
8	28	..	5·0	18·05	3·04	
8	56	..	5·0	18·0	3·05	
8	28	..	10·0	18·15	3·02	
8	..	5	5·0	18·1	3·03	Strong odour of chlorine.
8	..	10	5·0	17·7	3·12	
8	..	15	5·0	17·7	3·12	

Theoretical titre for reduction to Mn^{++} = 22·80
Mn^{+++} = 18·24.

noticed, this being more noticeable when the acid concentration was increased. In all cases in the absence of fluorides, reduction occurred to some stage intermediate between bivalent and trivalent manganese.

In the presence of fluorides the difficulty of detecting the end point was accentuated, the solutions being markedly coloured. However, the results given in Table V. show that trivalent manganese is the principal product. The results are not so consistent as those given earlier. There was an odour of chlorine in almost every case, and this, in some measure, explains the low titration values.

It is clear, then, that, as reported for manganous salts and arsenious acid, reduction of potassium permanganate by antimonious salts in the presence of fluorides proceeds only so far as trivalent manganese, except in the presence of considerable hydrochloric acid, according to the equation :—

$$2MnO_4^1 + 2Sb_2O_3 + 8H^+ \longrightarrow 2Mn^{+++} + 2Sb_2O_5 + 4H_2O.$$

LITERATURE CITED.

(1) Kessler.—Pogg. Annal., vol. cxviii, p. 17.
(2) Friedheim, C.—Leitfaden für die Quantitative Chemische Analyse.
(3) Skrabal.—Zeit. Anorg. Chem., 1904, vol. xlii, p. 1.
(4) Skrabal and Preiss.—Monatsh. f. Chem., 1906, vol. xxvii, p. 503.
(5) Holluta.—Zeit. Phys. Chem., 1922, vol. ci, p. 34.
(6) Holluta.—Zeit. Phys. Chem., 1923, vol. cvi, p. 276.
(7) Kropf.—Zeit. F. Angew. Chem., 1923, vol. xxxvi, p. 611.
(8) Hall and Carlson.—J. Amer. Chem. Soc., 1923, vol. xlv, p. 1615.
(9) Oryng.—Zeit. Anorg. Chem., 1927, vol. clxiii, p. 195; Roczniki Chem., 1927, vol. vii, p. 334.
(10) Holluta.—Zeit. Anorg. Chem., 1928, vol. clxviii, p. 361.
(11) Peters.—Zeit. Phys. Chem., 1898, vol. xxvi, p. 193.
(12) Müller and Koppe, Zeit. Anorg. Chem., 1910, vol. lxviii, p. 160.
(13) Metzger and Marrs.—J. Ind. Eng. Chem., 1911, vol. iii, p. 333.
(14) Metzger and Marrs.—J. Ind. Eng. Chem., 1913, vol. v, p. 125.
(15) Holluta and Obrist.—Monatsh. f. Chem., 1921, vol. xli, p. 555.
(16) Travers.—Bull. Soc. Chim., 1925, vol. xxxvii, p. 456.
(17) Swoboda.—Zeit. F. Anal. Chem., 1924, vol. lxiv, p. 156.

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE FRESHWATER ALGAE OF AFRICA.

9. *Freshwater Algae and Phytoplankton from the Transvaal.*

By GUNNAR NYGAARD (Copenhagen).

(Communicated by Miss E. L. STEPHENS.)

(With forty-eight figures in the Text.)

I. GENERAL PART.

About the beginning of this century our knowledge of the freshwater microflora of Africa was greatly increased through the publication of papers by J. Brunnthaler, G. B. De Toni, A. Forti, P. Hariot, F. Hustedt, E. Lemmermann, R. Muschler, O. Müller, C. H. Ostenfeld, W. Schmidle, B. Schröder, J. Virieux, W. and G. S. West, and J. Woloszynska.* Most of these publications dealt with the plankton and the algae of the large Central African lakes. Lately also O. Borge, W. Krieger, and P. van Oye have written about the algal flora of Equatorial Africa, and P. Frémy has published a large and important work on the blue-green algae of French Equatorial Africa. But our knowledge of the algal vegetation of South Africa is of more recent date. Already in 1910 and 1912 G. S. West had contributed to this knowledge, but it was not until 1918 and the following years that, through the publications of F. E. Fritsch and F. Rich, closer information about the freshwater algal flora of those subtropical regions was obtained. H. Printz, W. J. Hodgetts, and G. Huber-Pestalozzi have also published reports on the plankton and algae of South Africa, that of H. Printz being especially interesting from a plant geographical point of view, because it deals with subaerial algae.

When Professor C. H. Ostenfeld requested me to examine a number of samples of plankton and algae submitted to him by Professor C. E. Moss of Johannesburg, I was prepared to find the plankton associations, in spite of the wide geographical distribution of freshwater algae, somewhat different from the Danish ones. The conditions are subtropical; moreover, the climate in these regions is rather dry, and the consequent great evaporation

* See list of literature on p. 144.

may offer extreme conditions to the microflora in certain phases of the annual cycle.

All the samples, except two gathered in Natal and at Kazungula on the Zambesi River, were collected in the Transvaal. They comprise plankton as well as collections of algae from lakes, ponds, and rivers, and most of them were gathered in the period from December to April (especially February and March), *i.e.* during the summer. A few samples of plankton, which were very interesting, were collected in the winter—in July, August, and September. Professor Moss also submitted a series of slides with plankton and freshwater algae from the Transvaal.

One of the biological factors influencing the plankton and algal flora of the Transvaal is the temperature. J. Hann gives the following general description of the climate of the Transvaal (1911, p. 473): The winter half-year from April to September is dry and chill, especially at night; some days, on the other hand, are often as warm as in summer. The summer half-year from October to March is the rainy season. For further details I may refer to J. Hann, ii (1910), pp. 140–141, 147–149, 417; iii (1911), pp. 472–473.

Hann assumes an average height of 1200 metres above the sea for the Transvaal (iii, p. 473), and concludes that the mean temperature for the coldest month is some few degrees above 10° C., and for the warmest month some few degrees above 20° C. But in the neighbourhood of Johannesburg, where many of the samples of plankton and algae were taken, the mean temperatures, owing to the greater height above the sea (about 1700–1900 metres), are a little below 20° C. for the warmest, and a little below 10° for the coldest month. From the point of view of the submerged microflora the extremes are, however, of greater interest. These are some few degrees below freezing for the coldest, and 30° C. or more for the warmest months. For Johannesburg the extremes are thus ÷ 2·9° C. and 30·2° C. The daily variation of temperature is very considerable in the Transvaal; it may reach an average of 18·6° in winter (Hann, ii, p. 149). These figures show that *the shallow lakes and ponds* (e.g. *the "pans"*) *in winter nights may cool down to temperatures not much above freezing, while in summer they may reach day temperatures not far from* 30° *C.* The deeper lakes, of course, afford a considerably smaller daily and annual oscillation of temperature.

The temperatures entered on the labels of the samples range from 14° C. (Avenue Pan, May 6, 1928) to 26° C. (Rietfontein, March 19, 1928). The table below epitomises the sporadic measurements of temperature and pH available.

In the month of July, when the temperature of the air is near its annual minimum, water temperatures of 17·5–20° C. were observed, which shows that the day temperatures of the bodies of water may be high even in winter.

Localities	Date	Temperature	pH
Hartebeestpoort Dam . .	February 22	..	7·0
Rietkuil	,, 25	..	7·2
Lake Chrissie . . .	,, 27	..	8·9–9·2
Pan, near Breyton . .	,, 27	..	8·8
Brakpan	March 11	25° C.	7·1
Rietfontein	,, 19	26° C.	..
Barberspan	April 6	23·5° C.	9·1
Brakpan (small one) . .	May 6	16° C.	8·7
Avenue Pan	,, 6	14° C.	8·5
Vaal River, Vereeniging . .	July 25	17·5–20° C.	8·1–8·3

It is therefore evident that *the plankton and more especially the algal flora are exposed to extraordinarily great daily and annual oscillations of temperature.*

As might be expected in a country like the Transvaal, with a dry and subtropical climate, the pH measurements show neutral and alkaline values. The high hydrogen-ion concentrations that are generally connected with submerged Sphagnum,* and which are of common occurrence in Northern Europe, have not, according to the table above, been found in the Transvaal. Some of the pH values are very high, above 9·0. Professor Moss kindly supplied Professor Ostenfeld with a brief description of the localities from which the samples were collected. Professor Moss divides the localities into four groups :

1. *Artificial dams*, in connection with the gold mines. These are of little botanical interest.

2. *Semi-natural lakes, e.g.* Florida Lake, near Johannesburg. These are streams which have been dammed at one end. The mineral content is rather low. *Batrachospermum* occurs in the streams. Reed swamps (*Phragmites, Typha, Scirpus macrocarpus, Cyperus fastigiatus* are locally dominant) are present. Floating-leaved plants (*Limnanthemum thunbergianum, Potamogeton javanicus*) are found. Submerged plants (*Potamogeton javanicus, Potamogeton badius*, etc.) are not rare. There is a moderately rich plankton.

3. *Natural pans.*—The pans are shallow depressions, perhaps caused by the wind, but their origin is doubtful.

(*a*) Some always contain water, *e.g.* Lake Chrissie,† in the Eastern Transvaal.

(*b*) Usually they dry up in the winter, which is the dry season in Central

* v. G. Huber-Pestalozzi, 1930, p. 445.

† *Ibid.*, 1929, p. 362.

and South Africa (except in the south-west). As the water evaporates, the mineral content becomes very high, the water even becoming saturated, and white incrustations are left on the mud. *E.g.* Rietfontein, Avenue Pan, Brakpan, etc.

Zannichellia, Potamogeton pectinatus var., etc., occur in these pans, and also *Lemna "minor," Lemna "gibba"* and *Wolffia arhiza. Potamogeton Livingstonii* Ar. Bennett occurs in Lake Chrissie. The plankton of these natural pans is rich, especially after the early seasonal rains.

4. *River-dams.*—At Vereeniging, in the Southern Transvaal, the River Vaal has been dammed, the reservoir being the source of the drinking water of Johannesburg and of the whole of the Witwatersrand district. The pH is around 7·9. The mineral content is high, partly because a tributary (Klip River) flows through rocks of dolomite (magnesium-limestone). When the summer rains commence, the plankton must be very largely washed away. In winter, the plankton is exceedingly abundant—chiefly Copepods and Diatoms.

The plankton in the natural pans is a typical pond plankton, mainly consisting of organisms that must be designated as more or less littoral. It is first and foremost characterised by the occurrence of the large *Volvox Rousseletii* West, which was found in three of the localities. Further, *Microcystis aeruginosa* Kg. may occasionally attain a very great development in these ponds, and the ubiquitous *Botryococcus Braunii* Kg. also occurs here, and may sometimes be the dominant form. Besides these, the plankton in the natural pans consists mainly of Chlorophyceae. Among the species found in two or more localities (see Table on pp. 106–109, where samples 1–20 comprise the plankton from the natural pans) may be mentioned *Eudorina elegans* Ehrb., *Oocystis crassa* Wittr. var. *Marssonii* Printz, *Tetraëdron minimum* Hansg., *Scenedesmus armatus* Chodat var. *Chodati* Smith, and *Cosmarium scopulorum* Borge.

The plankton of the semi-natural lakes and river-dams is dominated by the Diatom *Melosira* (see table on pp. 106–109, where samples 23–26 comprise the plankton from Florida Lake and Vaal River Dam). I do not know where Rietkuil is to be placed in the system.* The samples from the three localities last mentioned are the only ones containing *genuine plankton organisms such as make up the plankton of larger bodies of water.* The plankton of Rietkuil is rather similar to that of the other two lakes, *Melosira* being the dominant form. More interesting, however, is the fact that the *Melosira-Anabaena* association, which G. S. West found in the large East African Lake Nyasa (*cf.* the photomicrographs on Plate 2 of West, 1907),

* Miss D. Weintroub informs me that Rietkuil is a fairly deep permanent pan, fed by springs and a stream, with no water-plants. It is about 700 metres long and 350 metres wide.—E. L. S.

occurs also in Rietkuil (S.E. Transvaal). The main forms in Nyasa (June–July, 1904) and Rietkuil (February, 1928) were *Melosira granulata* Ralfs var. *angustissima* Müller, and *Anabaena flos-aquae* Bréb. var. *intermedia* Woron. f. *spiroides* Woron.; while *Pediastrum simplex* Meyen var. *clathratum* (Schröter) and *Botryococcus Braunii* Kg. were also common to the two lakes.

This brief characterisation of the plankton in the natural pans, the semi-natural lakes, and the river-dams, as also the following general characterisation of the plankton of the Transvaal, should be accepted with some reservation. Preserved samples do not give a complete idea of the qualitative composition of the plankton, because most Flagellates and the naked Peridinieae (Gymnodinium, etc.) are either completely dissolved or quite unidentifiable in formalin material. For their recognition, examination of living plankton must be made. In the second place, as will be shown later, the qualitative composition of the plankton is subject to considerable variations, *i.e.* the organisms show a distinct periodicity in their annual life cycle. As we have no detailed knowledge of the succession of communities in the plankton of the South African lakes and ponds, the above characterisation is necessarily somewhat incomplete.

In order to show the composition of each single algal and plankton community, all the species present (with the exception of indeterminable ones, *e.g.* sterile species of Spirogyra) have been listed in the following table. The horizontal figures at the head of the table designate the individual samples (see p. 113). The designations ccc-cc-c-+-r-rr-rrr show the relative frequency of the species in the sample in question; ccc means that it was very abundant, cc that it was very common, c that it was common, + that it was fairly common, r that it was fairly rare, rr that it was rare, and rrr that only 1–3 specimens were observed.

All these statements are quite arbitrary. In certain cases, *e.g.* where only a slide was available, I have considered it more correct to put only an × in the column, as I do not know the frequency of the species in question in the locality itself.

If the statements of frequency for No. 23 (Florida Lake, August 28, 1927) are compared with those for No. 24 (the same locality thirteen days later), differences will be noticed in the case of certain organisms. Both *Dinobryon divergens* Imhof and *Peridinium bipes* Stein var. *occultatum* Lindem. were rare on August 28 (especially the former), while both were common on September 10. Further, quite a number of Chlorophyceae, as well as *Mallomonas alpina* Pasch. et Ruttn., although of rare occurrence, were found in the September sample, though missing in August. These facts suggest that *the plankton organisms in the lakes of the Transvaal may show a distinct periodicity in their annual life cycle.* This is still more

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Microcystis aeruginosa	..	ccc	rrr	..	..	..	..	..	r	r	..	..	..	..	..	..	..	..	..	rrr	+	..	rrr
„ *pulverea incerta*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Chroococcus turgidus	rrr																						
Gomphosphaeria aponina	+																						
„ „ *delicatula*	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..
Coelosphaerium Kützingianum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Merismopedia tenuissima	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *glauca*	rrr																						
Calothrix inserta n. sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gloeotrichia Raciborskii	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Anabaena flos-aquae var.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	c		
Cylindrospermum licheniforme tumidum n. var.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Spirulina abbreviata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Oscillatoria sancta	r																						
„ *princeps*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *chlorina*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *tenuis*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ „ *tergestina*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *chalybea*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *terebriformis tenera* n. var.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Lyngbya limnetica	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Plectonema Dangeardii	..	..	..	..	rrr																		
Microcoleus Hospita elongatus n. var.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cyclotella Meneghiniana	r	..	..	..	rrr																		
Coscinodiscus incomptus n. sp.	..	..	..	..	..	..	..	..	rrr	rrr	..	..	..	..	..	..	..	..	..	..	rrr	..	..
Melosira ambigua variata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	cc
„ *granulata*	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..
„ „ *angustissima*	..	..	..	rrr	rrr	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	cc	..	..
„ *varians*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tabellaria flocculosa	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr
Nitzschia longissima var.	..	..	..	..	..	..	..	..	..	rrr													
Surirella ovalis apiculata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Chrysococcus minutus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Mallomonas alpina	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Dinobryon divergens	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr
Phacus acuminata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *pleuronectes*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Trachelomonas volvocina	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *hispida*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ „ *crenulatocollis*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Peridinium bipes occultatum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r
Eudorina elegans	..	..	rrr	..	r	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Volvox Rousseletii	..	..	..	+	r	r	..	..	..	..	..	rrr											
Gloeococcus Schroeteri	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Characium limneticum	..	..	rrr																				
Pediastrum simplex clathratum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr		
„ *duplex clathratum*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ „ *reticulatum*	..	..	rrr	..	r	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ „ *asperum*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ „ *brachylobum*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *constrictum*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *Boryanum*	..	..	..	..	..	..	..	..	rrr	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..
Hydrodictyon reticulatum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *indicum ?*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

SAMPLES

22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
..	rrr	rrr												cc															
..	..	..	..	..	..	..	..	..	..	..	..	..	..																
															cc														
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..															
..	..	..	..	..	..	..	..	..	..	rrr																			
..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	c											
..	..	..	..	..	..	..	..	..	..	..	..	×																	
..	..	..	..	..	..	..	..	..	..	r	rrr																		
..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	
..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	
..	..	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	c	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r									
..	..	..	..	..	..	r																							
..	..	..	..	..	..	rrr	..	..	..	..	..	..	×															rr	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr										
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r											
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	c											
..	cc	cc																											
..	..	..	rrr	rrr															r										
..	..	..	cc	cc	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r	
..	..	..	rrr	..	..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		
..	rrr	rrr																											
																			rrr										
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr									
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..											
..	..	rr																											
..	rrr	c																rrr											
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..												
..	..	rrr																rrr	..	rr									
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	rrr									
..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr											
..	r	c																											
..	..	..	rrr	..	..	..	..	..	..	rr																			
..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr									
		rr																											
..	..	..	rrr	rrr																									rrr
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	rrr
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r	..	..	..	cc	
..	..	..	..	..	..	..	r	..	..	..	..	..	..	..	..	..	..	r											
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..												

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Lagerheimia subsalsa	..	..	..	..	..	..	..	..	rr	rr													
Oocystis crassa Marssonii	cc	..	..	..	..	..	..	..	r	r													
Tetraëdron minimum	rrr	..	..	..	..	..	..	..	rrr														
Dictyosphaerium pulchellum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *Ehrenbergianum*	..	..	..	..	..	..	..	..	rrr	rrr													
Scenedesmus acutiformis	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..
„ *armatus*	..	..	..	..	..	..	..	..	rrr	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..
„ „ *Chodati*	rrr	..	..	..	.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ „ *subalternans*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *dimorphus*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *opoliensis*	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *quadricauda*	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..
„ „ *quadrispina*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Crucigenia minima	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *fenestrata*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Coelastrum cambricum var.	..	..	..	..	rr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *reticulatum*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ankistrodesmus falcatus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ „ *spirilliformis*	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ulothrix punctata n. sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rhaphidonema brevirostre	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Draparnaldia Ravenelii	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Coleochaete orbicularis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Oedogonium pseudospirale n. sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *porrectum africanum* n. var.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *tapeinosporum Angolense*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Closterium acutum ?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr
„ *polystictum* n. sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *moniliferum ?*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *lineatum*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *peracerosum arcuatus*	rr																						
Euastrum evolutum integrius	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cosmarium margaritatum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *scopulorum*	cc	..	..	..	..	..	..	..	r	rr													
„ *subtumidum Klebsii*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *trachypleurum spinosum*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Staurastrum dejectum patens	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *paradoxum*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr
„ *bibrachiatum cymatium*	..	..	..	..	..	..	..	..	rrr	rrr													
Zygnema pectinatum	..	r	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Spirogyra Hoehnei robusta n. var.	..	..	..	..	..	..	..	..	..	..	..	rr											
„ *Reinhardi africana*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *scripta* n. sp.	..	..	..	..	..	..	..	..	..	..	..	cc											
Botryococcus Braunii	..	..	..	..	..	..	..	..	c	r	..	..	..	..	..	..	..	rrr	..	rrr	rrr	..	..
Chara coronata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
„ *fragilis*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Nitella sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

SAMPLES

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
..	..	..	..	rr																											
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr												
..	..	..	..	..	..	..	..	..	..	}	ccc	rrr	rrr																		
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr										
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	rrr	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr						
..	..	..	..	..	..	..	..	..	..	..	..	rr																			
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	ccc						
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr										
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr										
..	..	..	..	rr																											
..	..	..	..	rrr	..	..	..	..	..	..	..	rrr																			
..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr										
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr	..	..	..	rr						
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	cc		
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	c													
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr	rrr												
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	c									
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	cc									
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	r									
..	..	..	rrr																												
..	..	..	..	..	r	r							.																		
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr												
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rr												
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr												
..	..	..	..	..	..	..	..	..	..	..	..	rrr	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	rrr
..	..	..	..	rrr																											
..	..	..	rrr	rr																											
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+													
..	..	..	..	..	..	..	..	..	..	..	..	..	+																		
rrr	rrr	..	..	rrr																											
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×					
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×				
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×			

conspicuous in consideration of the fact that these changes in frequency have taken place within less than a fortnight.

More than one sample of plankton (see list of plankton samples on p. 113) was also available from Brakpan. Here the difference between that of September 9, 1927 (No. 1), and the autumn samples (February–April, Nos. 3–5) is very distinct. While the September sample mainly consisted of *Cosmarium scopulorum* Borge and *Oocystis crassa* Wittr. var. *Marssonii* Printz, and several Cyanophyceae, the autumn samples were characterised by the presence of quite different organisms, viz. *Volvox Rousseletii* West, *Eudorina elegans* Ehrb., *Pediastrum duplex* Meyen var. *reticulatum* Lag. etc. *Volvox Rousseletii* West shows a clear maximum in March. The maximum development of *Microcystis aeruginosa*, as in Northern Europe, seems to take place in the autumn (see Table). Regarding the curious periodicity of *Melosira granulata* Ralfs var. *angustissima* Müller, see p. 125.

Among the 98 species and varieties found there are 23 Cyanophyceae with 14 genera, 9 Diatomaceae with 6 genera,* 8 Flagellata with 6 genera, 1 Dinoflagellata, 54 Chlorophyceae with 26 genera, and 3 Characeae with 2 genera. Of these, 6 species and 5 varieties are described as new. The Cyanophyceae and Chlorophyceae are best represented.

The most noteworthy species may next be briefly mentioned. Although recorded from North and Central Africa, the widely distributed genus *Draparnaldia* has curiously enough not hitherto been recorded for South Africa. The very vigorous and characteristic *Draparnaldia Ravenelii* Wolle was, however, found in one of the natural pans. To my knowledge this species has not been met with since 1887, when it was described from North American material. The new species *Coscinodiscus incomptus* is of interest, since the genus is otherwise distinctly marine, only one species (*C. lacustris*) thriving in fresh water (estuaries and lakes). *Coscinodiscus incomptus*, which is very small and possesses an extremely delicate structure, was very common on *Potamogeton pectinatus* in Barberspan, one of the natural pans. The water is here occasionally very rich in salts, so that this species must also be designated as ecologically more or less halophilous. F. E. Fritsch found it in Griqualand West. On *Potamogeton pectinatus* were further found two new Cyanophyceae: *Microcoleus Hospita* var. *elongata* and *Calothrix inserta*. The latter is characterised by the row of short cells inserted in the upper third of the trichomes. *Ulothrix punctata* is a new species characterised by frequently having H-shaped pieces inserted in the walls of the cells, which bear some extremely small punctations.

Two new species and two new varieties of *Oedogonium* and *Spirogyra* are described. The plankton from the Vaal River at Vereeniging contained a

* Only the Diatomaceae occurring in the plankton have been determined.

peculiar *Closterium* with a large number of pyrenoids in the cells and characteristic apices; it has been named *Closterium polystictum* n. sp. Among other plankton organisms *Peridinium bipes* Stein var. *occultatum* Lindemann should be mentioned, since it has hitherto been recorded only from Germany. Other species requiring mention are *Cosmarium scopulorum* Borge and *Staurastrum bibrachiatum* Reinsch var. *cymatium* West. The former, described by O. Borge in 1923 from irrigated rocks in Sweden, was found in considerable quantity in the plankton of Brakpan on September 7, 1927, thus occurring under quite different ecological conditions. *Staurastrum bibrachiatum* Reinsch var. *cymatium* West, an easily identifiable alga, has only been recorded in very few cases. *Raphidonema brevirostre* Scherffel, finally, has hitherto been found only in the Tatra Mountains under alpine conditions.

G. S. West called attention to the fact that the *Melosira* filaments in the plankton from Nyasa, Victoria Nyanza, and Tanganyika were either quite straight or almost straight, and this is also the case in the Transvaal lakes. The *Melosiras* of the English and Danish lakes are likewise either straight or almost straight, but in the lakes of Iceland they are frequently, according to Ostenfeld, circularly coiled. That this feature is not associated with subarctic and temperate conditions alone is proved by the discovery of circularly coiled filaments in Lake Toba in 2° N. lat. (Nygaard, 1926, p. 233). The important rôle of this genus in the composition of the African plankton is shown not only by the table on p. 106, but also by the fact (according to the literature) that no less than seven different forms of it occur in Victoria Nyanza. On the other hand, *Tabellaria flocculosa* Kg., which is very common in the lakes and ponds of Northern Europe, is, according to the literature, very rare in Africa.

The occurrence of *Microcystis aeruginosa* Kg. and *Anabaena flos-aquae* Bréb. var. *intermedia* Woron. f. *spiroides* Woron. in the Transvaal lakes connects them rather closely with those of Central Africa, where the two genera mentioned play a considerable part. Another interesting record is that of *Peridinium bipes* Stein var. *occultatum* Lindem. in Florida Lake, for Peridinium is rare in the Central African lakes, though it has been recorded from several places in South Africa by G. Huber-Pestalozzi, F. E. Fritsch, and F. Rich. It is peculiar that *Ceratium hirundinella* Schrank was not found in a single Transvaal sample. It may no doubt be taken for granted that this generally distributed species is absent from the localities from which plankton samples were available, since it is perennial in subtropical lakes, and should therefore be present at the time when the plankton was collected. It has, moreover, been recorded only from very few places in Africa, *e.g.* from Victoria Nyanza.

Among the Flagellates the presence of *Dinobryon divergens* Imhof is

noteworthy, for the pelagic species of Dinobryon, which play so great a part in the plankton of Northern Europe, seem to be very rare in Africa.

The comparative paucity of Desmids in the samples is noteworthy,* except for the Vaal River Dam, where Closterium was rather conspicuous. Elsewhere, Desmids may sometimes occur in such great quantities in freshwater plankton as to warrant the term " Desmid plankton." This often occurs in tropical lakes, *e.g.* Victoria Nyanza, but in this respect the Transvaal lakes seem to be more closely related to Nyasa and Tanganyika with a plankton poor in Desmids.

In general, it will be seen that *the lake plankton of the Transvaal is not rich in species.* The richest is Florida Lake, which, however, in a single sample (No. 24) contained only 14 phytoplankton organisms. In a Danish alkaline lake, on the other hand, it is, as a rule, easy to find 30 species in a single sample. *The pond plankton of the Transvaal is also poor in species.* Thus Barberspan contained 13 phytoplankton organisms, which is the largest number found in any one sample from the natural pans. In Danish ponds, especially in contaminated ones, more than 50 organisms can be found in one sample. Such large numbers are, however, generally obtained only by a close examination of living plankton filtered through filter-paper ; plankton taken from Danish contaminated ponds with a tow-net never contains so many organisms.

The most interesting organisms of the plankton and algal flora of the Transvaal are to be found in the natural pans, where very extreme life conditions exist. Thus most of the specially interesting and of the new species described in the present work occur in the natural pans. A study of living plankton from the natural pans on the spot will no doubt bring to light a number of endemic Flagellates and Dinoflagellates. *In contrast with the pans the lakes of the Transvaal bear a much more cosmopolitan stamp.*

In the Systematic Part the geographical distribution of each species in Africa and in the surrounding islands has been added. I have not been able to see every paper named in the list of literature, although, with his usual liberality, Professor Ostenfeld placed all his literature on freshwater algae and plankton at my disposal. Even if the data on the geographical distribution of the various species cannot claim completeness, the few papers I have been unable to see will hardly alter materially the impression conveyed as to the distribution of each single species.

* Dr. Nygaard's samples were mainly from neutral or alkaline waters ; the naturally acid waters of the Transvaal are not necessarily so poor in Desmids or in phytoplankton generally. *Cf.* Miss Rich's account of the rich phytoplankton of Weltrevreden West pan (Transvaal), in her paper on " Phytoplankton from South African Pans and Vleis " in this volume.—E. L. S.

The name of the author responsible for the record is added in parentheses after each locality.

It is my pleasant duty to return my cordial thanks to Professor C. H. Ostenfeld for kindly submitting to me for examination the samples sent by Professor C. E. Moss, and for the helpfulness and interest with which he has followed this work.

After the completion and translation of my manuscript I received a paper, viz. G. Huber-Pestalozzi, " Das Plankton natürlicher und künstlicher Seebecken Südafrikas." This interesting treatise has the advantage over most papers dealing with the freshwater algae and plankton of Africa that the author has collected his samples himself, and thus knows the localities from personal observation. G. Huber-Pestalozzi distinguishes two types of water: *Vleys* and *Dams*. To judge from his description of these two types (*loc. cit.*, pp. 343–345, 379), the *natural pans* of Professor Moss described in the present work (see p. 103) are evidently identical with *Vleys*, and the *semi-natural lakes* and *river-dams* are identical with *Dams*. With reference to the phytoplankton of the two types he writes: " Das Phytoplankton in den Dams ist meist reich und typisch entwickelt, dasjenige in den Vleys dagegen meist arm und atypisch (viele Tychoplankter)." This statement agrees very well with the results of the present investigation. G. Huber-Pestalozzi also found that the three phytoplanktonts *Microcystis aeruginosa* Kg., *Melosira granulata* Ralfs and var. *angustissima* Müll. and the ubiquitous *Botryococcus Braunii* Kg. are widely distributed in South Africa, both in Vleys and in Dams.

Volvox Rousseletii West, which is endemic in South Africa and characteristic of the natural pans, is not recorded. This is probably due to the fact that G. Huber-Pestalozzi collected his material during the months of September–November, a period in which this species—at least in the Transvaal—does not seem to be present in the plankton (see p. 106). The author concludes with the following statement (p. 375): " Wir haben eine Lebens- und Formenwelt von fast absolut kosmopolitischem Einschlag vor uns, mit einem Grundstock banaler Ubiquisten, gemischt z. T. mit Lokalrassen weitverbreiteter Arten, z. T. auch wohl endemischer Species."

LIST OF PLANKTON SAMPLES.

Lakes and Ponds.

1. Brakpan, Witwatersrand, plankton, September 7, 1927, coll. 85, leg, M. E. Blenkiron.
2. Brakpan, pond scum; pond recently filled after rains, February 14, 1928, coll. 47, leg, D. Weintroub.

3. Brakpan, Witwatersrand, plankton, February 19, 1928, coll. 82, leg, M. E. Blenkiron.
4. Brakpan, Witwatersrand, plankton, March 11, 1928, t. = 25°, pH = 7·1, coll. 49, leg, M. E. Blenkiron.
5. Brakpan, Witwatersrand, plankton, April 15, 1928, coll. 53, leg, G. E. H.
6. Brakpan, small pan near station, plankton, May 6, 1928, t. = 16°, pH = 8·7, coll. 60, leg, M. E. Blenkiron.
7. Avenue pan, near Johannesburg, plankton, May 6, 1928, t. = 14°, pH = 8·5, coll. 59, leg, M. E. Blenkiron.
8. Pan about ½-mile from Breyton station, North Transvaal, plankton, February 27, 1928, pH = 8·8, coll. 81, leg, G. E. H.
9. Barberspan, West Transvaal, plankton, April 6, 1928, t. = 23·5°, pH = 9·1, coll. 55, leg, M. E. Blenkiron.
10. Barberspan, West Transvaal, plankton from mouth of channel, April 6, 1928, t. = 23·5°, pH = 9·1, coll. 103, leg, M. E. Blenkiron.
11. Rietfontein, Witwatersrand, near Johannesburg, plankton from comparatively clear and deep (3–4′) water, March 8, 1928, coll. 92, leg, M. E. Blenkiron.
12. Rietfontein, Witwatersrand, rough heleoplankton, March 10, 1928, coll. 51, leg, M. E. Blenkiron.
13. Rietfontein, Witwatersrand, plankton, March 19, 1928, t. = 26°, coll. 83, leg, M. E. Blenkiron.
14. Rietfontein, coll. 48, leg, M. E. Blenkiron.
15. Blaauwater No. 1, S.-E. Transvaal, plankton, February 27, 1928, coll. 75, leg, M. E. Blenkiron.
16. Blaauwater No. 2, S.-E. Transvaal, plankton, February 27, 1928, coll. 76, leg, M. E. Blenkiron.
17. Lake Chrissie, S.-E. Transvaal, plankton from Potamogeton zone, February 25, 1928, pH = 9·2, coll. 78, leg, M. E. Blenkiron.
18. Lake Chrissie, S.-E. Transvaal, plankton from open waters, February 27, 1928, pH = 9·2, coll. 77, leg, M. E. Blenkiron.
19. Lake Chrissie, S.-E. Transvaal, plankton from open waters, washed, February 27, 1928, pH = 8·9, coll. 79, leg, M. E. Blenkiron.
20. Lake Chrissie, S.-E. Transvaal, plankton from Potamogeton zone, February 27, 1928, pH = 8·9 coll. 74, leg, M. E. Blenkiron.
21. Rietkuil, Bethal district, S.-E. Transvaal, plankton, February 25, 1928, pH = 7·2, coll. 73, leg, M. E. Blenkiron.
22. Alberton, Witwatersrand, near Johannesburg, plankton, March 25, 1928, coll. 86, leg, M. E. Blenkiron.
23. Florida Lake, Witwatersrand, plankton, August 28, 1927, coll. 93, leg, M. E. Blenkiron.

24. Florida Lake, Witwatersrand, plankton, September 10, 1927, coll. 84, leg, M. E. Blenkiron.
25. Vaal River, Vereeniging, ¼-mile downstream from Pumping station, plankton, July 25, 1928, t. = 17·5°, pH = 8·1, 0_2 = 3·12 pts./mill., coll. 90, leg, M. E. Blenkiron.
26. Vaal River, Vereeniging, plankton from opposite outlet, July 25, 1928, t. = 20°, pH = 8·2 – 8·3, 0_2 = 3·92 pts./mill., coll. 91, leg, M. E. Blenkiron.
27. Shelter Falls, Howick, Natal, plankton, January 21, 1928, coll. 100, leg, M. E. Blenkiron.

Rivers.

28. Ndawalene River, Pondoland, plankton, January 1, 1928, coll. 98, leg. M. E. Blenkiron.
29. Ndawalene River, Pondoland, plankton, January 1, 1928, coll. 101, leg. M. E. Blenkiron.
30. Msiswanga River, Pondoland, near Lusikisiki, plankton from quiet backwater, 1′–2′ deep, January 9, 1928, coll. 102, leg, M. E. Blenkiron.
31. Lukalla (or Lolalo) River, Pondoland, plankton, December 23, 1927, coll. 97, leg, M. E. Blenkiron.
32. Mtakati River, Pondoland, plankton occluded with Chara and Nitella, December 24, 1927, coll. 96, leg, M. E. Blenkiron.
33. Mtakati River, Pondoland, plankton, among water weeds, December 24, 1927, coll. 99, leg, M. E. Blenkiron.

LIST OF ALGAE SAMPLES.

Lakes and Ponds.

34. Brakpan, Witwatersrand, alga, May 21, 1926, coll. 69, leg, D. Weintroub.
35. Brakpan, Witwatersrand, alga, March 16, 1927, coll. 68, leg, D. Weintroub.
36. Brakpan, Witwatersrand, forming pink, gelatinous mass, free floating on the water, September 4, 1927, coll. 65, leg, D. Weintroub.
37. Brakpan, Witwatersrand, on wet ground at edge of pan at Brakpan, August 20, 1927, coll. 71, leg, D. Weintroub.
38. Rietfontein, Witwatersrand, algae, April 21, 1928, coll. 58, leg, G. E. H.
39. Rietfontein, Witwatersrand, algae, free floating with *Utricularia* sp., March 31, 1928, coll. 87, leg, G. E. H.
40. Barberspan, West Transvaal, algae on *Potamogeton pectinatus*, April 4, 1928, t. = 23·5°, pH = 9·1, coll. 54, leg, M. E. Blenkiron.

41. Vereeniging water-works, South Transvaal, mud from filter bed, July 25, 1928, coll. 89, leg, M. E. Blenkiron.
42. Alberton, near Johannesburg, floating scum, pond near station, March 25, 1928, coll. 92, leg, M. E. Blenkiron.
43. Egossa Forest, Mtsabane, Lusikisiki district, algae, January 10, 1928, coll. 106, leg, M. E. Blenkiron.
44. Forest Hill, near Johannesburg, algae on drying mud, February 19, 1928, coll. 80, leg, M. E. Blenkiron.
45. Geduld Dam, greenish mud, March 17, 1928, coll. 52, leg, M. E. Blenkiron.
46. Pan at Brakpan, Witwatersrand, Characeae, November 1927, coll. 2, leg, D. Weintroub.
47. Pan at Brakpan, Witwatersrand, Characeae, August 20, 1927, coll. 1, leg, D. Weintroub.
48. Pan at Rietfontein, Witwatersrand, Characeae, February 22, 1928, coll. 3, leg, D. Weintroub.

RIVERS.

49. Alberton, Witwatersrand, near Johannesburg, green alga attached to rocks in waterfall, March 25, 1928, coll. 94, leg, M. E. Blenkiron.
50. Stream near Port St. Johns, Pondoland, plankton and algae (scum) from pond, January 1, 1928, coll. 107, leg, M. E. Blenkiron.
51. Zambesi River, Kazungula, algae occluded with water plants, September 1927, coll. 42, leg, K. G. Berrell.

II. Systematic Part.

CYANOPHYCEAE

CHROOCOCCACEAE

1. *Microcystis aeruginosa* Kg., Tab. Phyc. I, p. 6, t. 8; L. Geitler, 1925, p. 58, fig. 37 (fig. 40 = *Microcystis viridis* Lemm.).

The mucilage of the colonies did not possess the highly refractive coat characteristic of *M. viridis* Lemm. The cells were 3–4 μ in diameter. This widely distributed species is obviously common in the Transvaal (see the list of localities below). In Northern Europe it occurs as a perennial plankton organism; some few colonies survive the winter under the ice. In the Transvaal it is likewise perennial, being found both in the cold months of August and September and in the warm month of February. A great development resulting in the formation of "water-bloom" took place in the beginning of February 1928 in one of the natural pans (Brakpan), shortly after the pond had been filled with rain-water (No. 2).

In the plankton of Brakpan (Nos. 2 and 3), Barberspan (Nos. 9 and 10), Lake Chrissie (No. 20), Rietkuil (No. 12), and Florida Lake (Nos. 23 and 24).

Distr. in Africa*: Brit. East Af., Victoria Nyanza (C. H. Ostenfeld, G. S. West, J. Woloszynska), Tanganyika (according to P. Frémy), Nyasa (W. Schmidle, G. S. West), Mohasi Lake (E. Lemmermann), Itende Lake (W. Schmidle); **South Africa,** Rhodesia, Transvaal, Cape Colony (G. Huber-Pestalozzi), Natal (F. E. Fritsch and F. Rich); Madagascar (F. E. Fritsch).

2. *Microcystis pulverea* Mig. var. *incerta* Crow, 1923, p. 66; E. Lemmermann, 1901, p. 93, t. 4, fig. 8.

The single small colonies had coalesced to form large masses. The cells were 1–2 μ in diameter. In contrast to *M. aeruginosa*, which, as in Northern Europe, may develop in great abundance in the autumn, this species perhaps reaches its maximum in the spring (Brakpan, September 1927). In Northern Europe it may be very common in pond plankton in late summer.

Free floating on the water, Brakpan (No. 36).

Distr. in Africa: Brit. East Af., Victoria Nyanza (C. H. Ostenfeld, G. S. West), Tanganyika (G. S. West).

3. *Chroococcus turgidus* Näg., 1849, p. 46; M. Cooke, 1882, t. 83, fig. 2.

This widely distributed alga was only found in one sample. Cells 20–28 μ broad without teguments, 34–45 μ with teguments.

In the plankton of Brakpan (No. 1).

Distr. in Africa: North Africa, Algeria (C. Sauvageau), Libya (according to P. Frémy), Egypt (G. S. West); **French Equatorial Africa,** Gaboon (P. Frémy); **Brit. East Af.** (G. Hieronymus, W. and G. S. West, W. Schmidle), Nyasa, Tanganyika (G. S. West), Victoria Nyanza (J. Woloszynska); Angola (W. and G. S. West); **S. Africa,** Griqualand West, Natal (F. E. Fritsch and F. Rich), Little Namaqualand (G. S. West), Cape Colony (F. E. Fritsch and E. Stephens, P. Reinsch, G. S. West, G. Huber-Pestalozzi); Azores (K. Bohlin, W. Krieger).

4. *Gomphosphaeria aponina* Kg., Tab. Phyc. I, t. 31, fig. 3; P. Frémy, 1930, p. 34, fig. 39.—**(Fig. 1.)**

Colonies 55–70 μ in diameter; each cell with a thin special tegument, colour olive-green or pale blue-green, contents granular; cells 5–8 μ broad, 8–11·5 μ long; number of cells in a colony about 80.

In the plankton of Brakpan (No. 1).

Distr. in Africa: North Africa, Algeria (according to P. Frémy), Cyrenaica (G. B. De Toni and A. Forti); **Brit. East Af.** (W. Schmidle), Victoria Nyanza (J. Virieux), Tanganyika (G. S. West); **French Equatorial Africa,** Gaboon (P. Frémy); **S. Africa,** Little Namaqualand (G. S. West), Cape Colony (F. E. Fritsch and E. Stephens).

Var. *delicatula* Virieux; L. Geitler, 1925, p. 99.—**(Fig. 2.)**

Colonies 50–70 μ in diameter; each cell with a thin special tegument, colour intense blue-green, contents homogeneous, cells 2·5–4 μ broad, 6–8 μ long; number of cells in a colony about 200.

On wet ground at edge of pan at Brakpan (No. 37, abundant in the slide), in the plankton of Rietfontein (No. 11).

Distr. in Africa: not recorded in the literature.

For the sake of comparison I have added a figure and diagnosis of var. *multiplex* Nygaard, 1926, p. 204, t. 3, fig. 24.—**(Fig. 3.)**

Size of colonies 70–125 μ, average considerably above 70 μ, *e.g.* the daughter-colonies immediately after a division being 90 and 100 μ respectively. Each cell with a thick special tegument, colour blue-green, contents granular; cells 5–8 μ broad, 13–17 μ long, number of cells in a colony about 200.

5. *Coelosphaerium Kützingianum* Nägeli, 1849, p. 54, t. 1 C. (*C. Kützingianum* Kirchner (non Nägeli) in Engler und Prantl's Natürl. Pflanzenfam. I, 1a, fig. 50 A = *C. Nägelianum* Unger).

In the plankton of Mtakati River (No. 32).

Distr. in Africa: Brit. East Af. (O. Borge, W. Schmidle), Victoria Nyanza (C. H. Ostenfeld); **French Equatorial Africa,** Gaboon (P. Frémy); **S. Africa,** Cape Colony (F. E. Fritsch and E. Stephens).

---

* In these distribution lists, the Cape Province is cited under its former title of "Cape Colony," and records from Griqualand West and Little Namaqualand are listed under the names of these areas instead of under "Cape Colony," of which these are geographically a part.

6. *Merismopedia tenuissima* Lemmermann, 1899, p. 37, t. 1, fig. 21.

The cells were 1–2 μ in diameter.

In the plankton of Brakpan (No. 1), and Mtakati River (No. 32).

Distr. in Africa: North Africa, Algeria, Tunis (according to P. Frémy); **Brit. East Af.,** Tanganyika (according to P. Frémy), Mohasi Lake (E. Lemmermann); **French Equatorial Africa,** Ubangi, Gaboon (P. Frémy); **South Africa,** Griqualand West (F. E. Fritsch and F. Rich), Little and Great Namaqualand, Cape Colony (G. S. West).

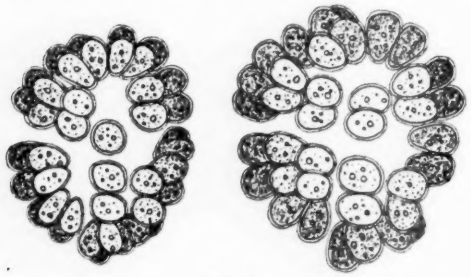


FIG. 1.

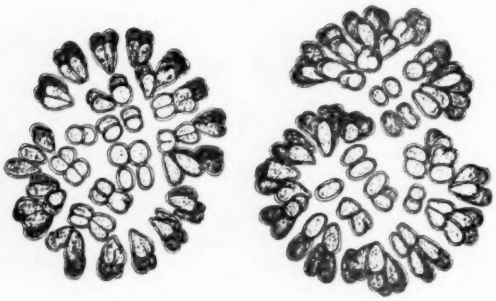


FIG. 2.

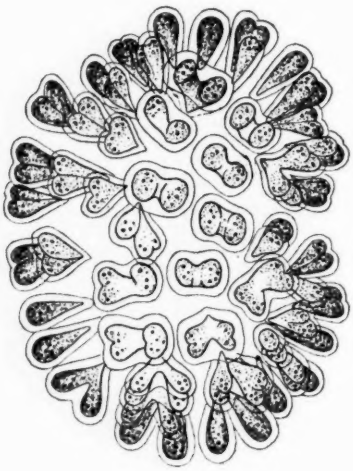


FIG. 3.

FIG. 1.—*Gomphosphaeria aponina* Kg. FIG. 2.—Var. *delicatula* Virieux. FIG. 3.—Var. *multiplex* Nygaard, original material from the Key Islands. All ×640.

7. *Merismopedia glauca* Nägeli, 1849, p. 55, t. 1 D, fig. 1; P. Frémy 1930, p. 13, fig. 9.

Colonies mostly small, with 16 cells. Cells 4–5 μ broad, 5·5–6·5 μ long immediately after division, embedded rather loosely in the mucus; distance between the cells sometimes as great as their length.

In the plankton of Brakpan (No. 1).

Distr. in Africa: North Africa, Algeria (F. Debray), Libya (G. B. De Toni and A. Forti); **French Equatorial Africa,** Gaboon (P. Frémy); **Brit. East Af.** (O. Borge), Kenya Colony (W. and G. S. West), Nyasa, Tanganyika (G. S. West), Victoria Nyanza (G. S. West, J. Woloszynska); Angola (W. and G. S. West); near Zambesi River (H. Schinz, N. Wille); **South Africa,** Transvaal (G. Huber-Pestalozzi), Griqualand West, Natal (F. E. Fritsch and F. Rich), Little Namaqualand (G. S. West), Cape Colony (F. E. Fritsch and F. Rich, G. S. West, G. Huber-Pestalozzi), Orange Free State (F. E. Fritsch); Azores (K. Bohlin).

RIVULARIACEAE

8. *Calothrix inserta* n. sp.—**(Fig. 4.)**

Thallus very small, cushion-like, pale blue-green, encrusted with lime. *Filaments* not branched, almost straight or slightly curved, more or less parallel and arising erectly from the substratum, not bulbous at the base, up to 500 μ in length, 10–11 μ thick at the middle, 15–17 μ at the base. ***Sheaths*** colourless, firm and not lamellose at the base, upwards agglutinated in the outmost layer and distinctly lamellose (with up to 5 layers); the outer layers often detached; sheaths longer than the trichomes. *Trichomes* intensely blue-green, regularly attenuated from base to apex, sometimes with a bulbous swelling at the base, where the trichomes are 8–9 μ thick and distinctly constricted between each pair of cells; breadth of cells here up to three times their length; at the middle the trichomes are about 5 μ in breadth, with no constriction at the septa, the cells as long as broad, or up to twice as long as broad; near the apices of the trichomes the cells again shorter (presumably an intercalary meristem), up to three times as broad as

long, and not constricted at the septa ; the apices of the trichomes themselves are hair-like, 1–3 μ in breadth, more or less hyaline and consisting of few cells, which are up to four times as long as broad or perhaps still longer. *Heterocysts*

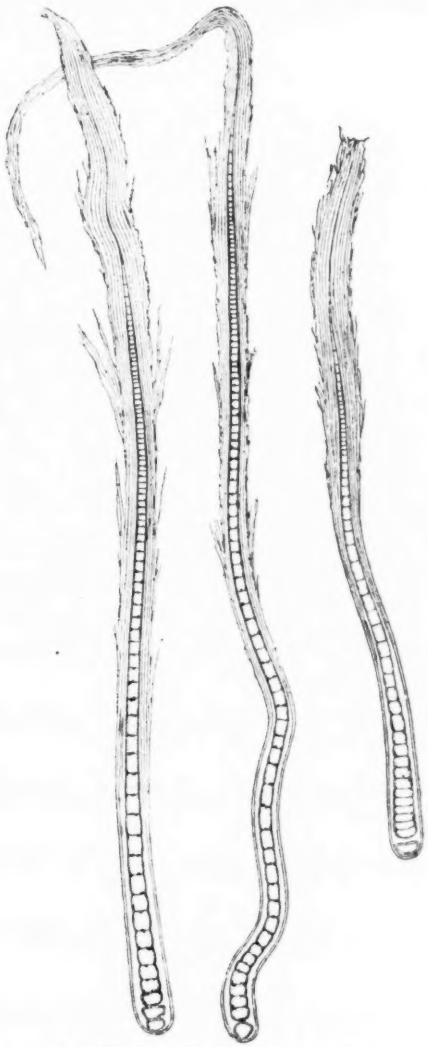


FIG. 4.—*Calothrix inserta* n. sp. × 349.

basal, never intercalary, solitary or two together, often hemispherical, 8–10 μ in breadth. *Cell-contents* homogeneous, mostly with 1 or 2 dark granules at the septa. Spores not found.

On *Potamogeton pectinatus*, Barberspan (No. 40).

The species is characterised by its distinctly lamellose and strongly agglutinated sheaths, and by the peculiar structure of the cells.

Judging by the published diagnoses and figures none of the species hitherto described have a row of very short

cells near the apex of the trichomes. The species was found at a temperature of 23·5° C. and a pH value of 9·1; it is no doubt to be regarded as more or less halophilous.

9. *Gloeotrichia Raciborskii* Woloszynska, 1912, p. 687, text-fig. 12.—**(Fig. 5.)**

Thallus small, about 1 or 2 mm. in diameter, soft, filaments easily separated by pressure, certain trichomes running out into a long hyaline hair, missing in others. *Vegetative cells* pale blue-green, shortly cylindrical, rounded at the septa, so that the trichome is distinctly constricted. Broadest cells at the base of the trichome 9–15 μ broad, narrower cells (2–7 μ in breadth) being found at the apex of the trichome. Shortest cells at the middle (breadth up to four times the length) where they form an intercalary meristem. Longest cells at the apex of the trichome; cell-walls in the delicate hair-apices very indistinct, but cells were measured, the length of which was 4–5 times their

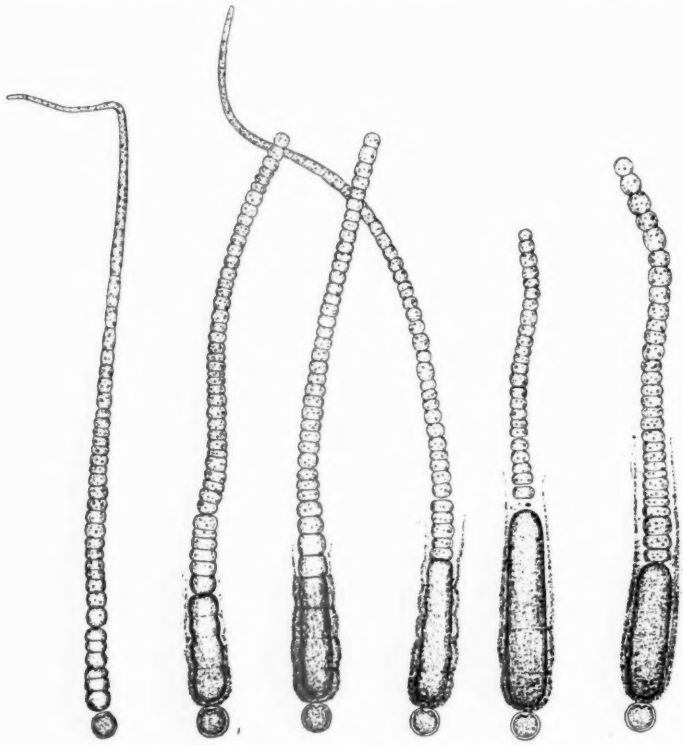


FIG. 5.—*Gloeotrichia Raciborskii* Wolosz. ×372.

breadth. Cell-contents granular. *Heterocysts* solitary, basal, spherical, 10–14 μ in diameter. *Resting-spores* long, cylindrical or slightly conical, with broadly rounded extremities, membrane smooth, colour?; *sheaths* invisible on the non-sporiferous trichomes; at the base of the sporiferous trichomes there always occurs a closely attached, firm, granular, intensely light-brown sheath, enclosing the spore and a short row of cells above this. Spores 55–83 μ long, 14–23 μ broad.

In Brakpan (No. 34).

The formation of the spore takes place by the basal cells of the trichome growing rapidly both in length and breadth. At the same time the formation of the sheath commences around the lower cells. The young sheath is only very slightly brown-coloured and is constricted like the trichome. Later it becomes granular and intensely light-brown and closely attached to the spore.

In examining the material of this *Gloeotrichia* the possibility occurred to me that in this species the spores do not originate from a single basal vegetative cell, but by a fusion of two or more basal cells. The following facts speak in favour of this view. When a trichome is about to form a spore, not only the basal cell but also the cells above it increase in size (see fig. 5). The cell-walls between these large basal cells are very indistinct; in the more advanced

stages it is not possible, in view of the opacity of the brown sheath, to determine whether or not the slightly constricted spore has any septa. It was further observed that the shortest cells (the intercalary meristem) in non-sporiferous trichomes were situated almost at the middle. If the spore is formed solely by the basal cell, the meristem must be removed from the heterocyst by at least as much as the length of the spore, and must thus be situated considerably above the middle of the trichome. The situation of the intercalary meristem is not always easily determined in the sporiferous trichomes, but in several cases it was obviously situated near the middle and not above the middle of the trichome. This would seem to indicate that the spore is not formed by rapid growth in length and breadth of the single basal cell, but by a fusion of a row of basal cells. A cytological investigation would be of interest, for *this fusion seems to indicate that sexual reproduction within the class Cyanophyceae may be found!*

Among the thirteen known species of *Gloeotrichia* the present species is most closely related to *G. Raciborskii* Wolosz. This species differs from the present specimens in unessential points, viz. by having lamellose and sometimes (?) ochreate sheaths. *G. Lilienfeldiana* Wolosz. practically only differs from *G. Raciborskii* Wolosz. in having colourless sheaths, which seems to me insufficient for the establishment of a separate species.

Distr. in Africa: not recorded in the literature.

NOSTOCACEAE

10. *Anabaena flos-aquae* Bréb. var. *intermedia* Woronich. f. *spiroides* Woronich.; L. Geitler, 1925, p. 324 (Syn.: *Anabaena flos-aquae* Bréb. forma, G. S. West, 1907, p. 169, t. 4, figs. 10–11, 14–15; t. 10, fig. 1).—**(Fig. 6.)**

Trichomes solitary, free-floating, greatly twisted, generally in the form of spirals with 1–2 coils, but trichomes with up to five coils in a loose spiral, as also some rather irregularly coiled trichomes found. *Vegetative cells* spherical,

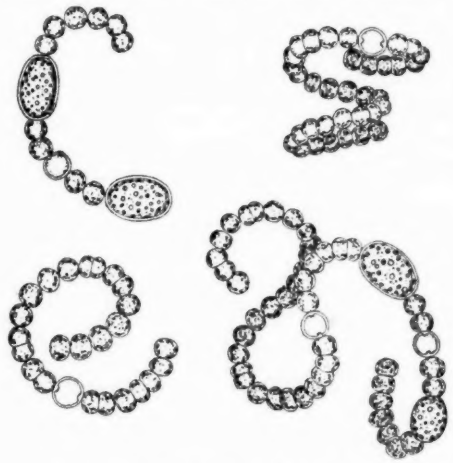


FIG. 6.—*Anabaena flos-aquae* Bréb. var. *intermedia* Woron. f. *spiroides* Woron. ×604.

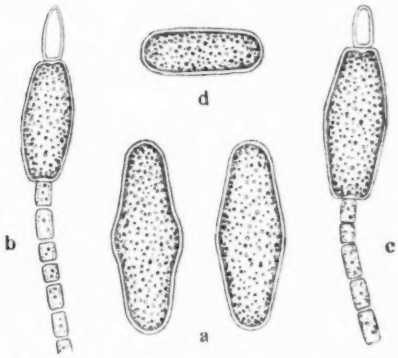


FIG. 7.—*Cylindrospermum licheniforme* Kg. var. *tumidum* n. var. ×755.

or shorter than broad, with pseudo-vacuoles, 5·5–6 μ in diameter. Sheaths invisible. *Heterocysts* always spherical, 6·5–7 μ in diameter. *Spores* always distant from the heterocysts, mostly two in each sporiferous trichome, never in series, contents granular, shape elliptical, sometimes slightly unsymmetrical; length, 16–16·5 μ; breadth, 10–11 μ; membrane smooth, colourless.

In the plankton of Rietkuil (No. 21).

To judge from its great abundance the species had presumably developed water-bloom.

Anabaena Westi Virieux (1913, p. 5, t. 1, fig. 1) is very closely allied to this variety of *A. flos-aquae* Bréb.; both differ from the type by having solitary trichomes. Virieux's specimens, which were sterile, however, possess rather thin trichomes, 3–4·5 μ broad, so that they can hardly be identical with the present specimens.

Distr. in Africa: Brit. East Af., Tanganyika (G. S. West), Nyasa (W. Schmidle, G. S. West).

11. *Cylindrospermum licheniforme* Kg., var. *tumidum* n. var.—**(Fig. 7.)**

Trichomes more or less twisted and pale blue-green; *vegetative cells* cylindrical, 3·5–4 μ broad, 4–7 μ long, with granular contents; intercalary *heterocysts* oval, 4·5 μ in breadth, 7–7·5 μ in length, terminal heterocysts more or less conical, 4·5 μ broad and 8–11 μ long; *spores* generally distinctly tumid in the middle, with broadly rounded extremities and granular, brownish contents, 10–14 μ broad, 25–38 μ long, membrane smooth, of a pale red-brown colour.

In the plankton of Mtakati River (Nos. 32–33).

The presence of thalli of this species in the plankton is, of course, due to a mere chance, as it is no plankton organism. The mature spores are very characteristic, being broadly rounded at the extremities and tumid in the middle (fig. 7*a*); a spore that was 14 μ wide in the middle, measured only 9 μ at the apices. Another, extremely rare, form of spore was subrhombic with truncate poles (fig. 7*c*), 12·5 μ wide in the middle, but 8 μ at the poles. Spores with parallel-sided walls were also observed (fig. 7*d*), but these were fairly rare. The mature spores were hardly ever less than 12 μ in breadth and 30 μ in length.

The new variety differs from the type in its peculiar spores.

OSCILLATORIACEAE

12. *Spirulina abbreviata* Lemmermann, 1910, p. 119, 91, fig. 13.

The trichomes, which were of a pale blue-green colour and a little pointed at the extremities, measured 3 μ in breadth and 23 μ in length; breadth of the spiral about 10 μ.

In the plankton of Ndawalene River (No. 28), stream near Port St. Johns (No. 50).

Distr. in Africa: not recorded in the literature.

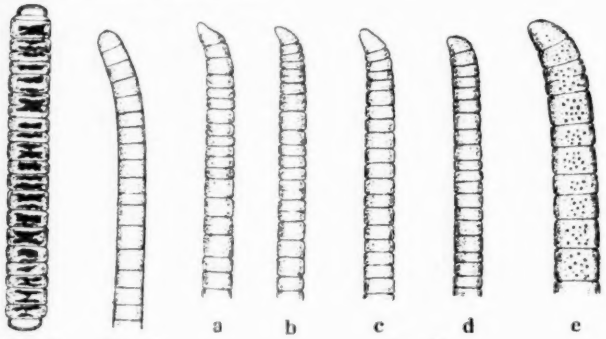


FIG. 8. FIG. 9. FIG. 10.

FIG. 8.—*Oscillatoria sancta* Kg. ×465. FIG. 9.—*Oscillatoria tenuis* Ag. var. *tergestina* Rab. ×755.
FIG. 10.—*Oscillatoria chalybea* Mert., *a–d* (×465) from Ndawalene River, *e* (×755) from Port St. Johns.

13. *Oscillatoria sancta* Kg.; M. Gomont, 1893, p. 229, t. 6, fig. 12.—**(Fig. 8.)**

Trichomes short, 50–240 μ long, often with a thickened calyptra at both extremities, 14–17·5 μ wide; cells 3–6 μ in length.

In the plankton of Brakpan (No. 1).

This species was rather frequent in the plankton of this locality. The fact that there is often a prominent calyptra at either extremity of even very short trichomes, seems to show that this form is able to remain floating in the water for some time.

Distr. in Africa: North Africa, Algeria, Morocco (according to P. Frémy); **French Equatorial Africa,** Gaboon (P. Frémy); **Brit. East Af.,** Nyasa and surrounding country, Rukuga Lake (W. Schmidle); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich), Cape Colony (F. E. Fritsch and E. Stephens); Azores (K. Bohlin).

14. *Oscillatoria princeps* Vauch.; M. Gomont, 1893, p. 226, t. 6, fig. 9.

Thickness of trichomes, 30–33 μ.

In the plankton of Ndawalene River (No. 28), stream near Port St. Johns (No. 50).

Distr. in Africa: North Africa, Algeria (F. Debray), Libya (according to P. Frémy); **French Equatorial Africa,** Ubangi, Gaboon (P. Frémy); **Brit. East Af.,** Albert Nyanza, Tanganyika (G. S. West), Mohasi Lake (E. Lemmermann); **S. Africa,** Griqualand West, Natal (F. E. Fritsch and F. Rich), Cape Colony (G. S. West, F. E. Fritsch and E. Stephens); Réunion (*v.* Jadin, 1890, p. 158).

15. *Oscillatoria chlorina* Kg.; L. Geitler, 1925, p. 361, fig. 439*b*.

The specimens corresponded closely with the diagnosis in Geitler's paper; the hyaline "Plasmakuppe" was observed on nearly all the trichomes. Thickness 3–5 μ.

In stream near Port St. Johns (No. 50).

Distr. in Africa: Brit. East Af., Tanganyika (according to P. Frémy); **S. Africa,** Little Namaqualand (G. S. West).

16. *Oscillatoria tenuis* Ag.; M. Gomont, 1893, p. 240, t. 7, figs. 2–3.

Floating scum on pond near Alberton (No. 42).

Distr. in Africa: North Africa, Algeria (F. Debray, C. Sauvageau), Morocco (according to P. Frémy), Egypt J. Brunnthaler); Abyssinia (G. B. De Toni); **French Equatorial Africa,** Gaboon (P. Frémy); **Brit. East Af.** (O. Borge,

W. Schmidle), Victoria Nyanza, Tanganyika, Albert Nyanza (G. S. West), Rukuga Lake (W. Schmidle); Angola (W. and G. S. West); **S. Africa,** Transvaal (G. Huber-Pestalozzi), Griqualand West, Natal (F. E. Fritsch and F. Rich), Little Namaqualand (G. S. West), Cape Colony (G. S. West, F. E. Fritsch, and E. Stephens); Azores (K. Bohlin), Madagascar (F. E. Fritsch).

Var. *tergestina* Rab.; M. Gomont, 1893, p. 241.—**(Fig. 9.)**

Trichomes solitary, more or less straight, 4–5 μ broad, not constricted at the septa, pale blue-green, not tapering towards the extremities, which are sometimes slightly curved. Cells as long or half as long as broad, 2·5–5 μ long, not or extremely rarely granular at the indistinct septa. Apical cell broadly rounded, without calyptra.

In the plankton of Ndawalene River (No. 28).

The present specimens differ from *O. tenuis* Ag. var. *tergestina* Rab. in having unconstricted trichomes and non-granular septa. That no great systematic importance can be attached to these facts is evident from Gomont's diagnosis, which states that the trichomes are ***generally*** slightly constricted at the septa, and that the latter are often granular. G. M. Smith has figured *O. tenuis* Ag., var. *tergestina* Rab. without granules at the septa (1920, t. 7, figs. 7–8), but in his diagnosis (*loc. cit.* p. 52) no mention is made of this. It thus remains an open question whether his specimens were really non-granular at the septa.

Distr. in Africa: Cameroun (O. Nordstedt); **Brit. East Af.,** near Rukwa, Nyasa (W. Schmidle).

17. *Oscillatoria chalybea* Mertens; M. Gomont, 1893, p. 252, t. 7, fig. 19.—**(Fig. 10.)**

Trichomes solitary, straight, only curved at the level of the terminal cell or of the two terminal cells, slightly constricted at the distinct septa, from 8–10 μ thick, olive-green (No. 28) or intensely blue-green (No. 50), cells $\frac{1}{2}$–$\frac{3}{4}$ as long as broad, 3–6 μ long, not granular at the septa. Apical cell a more or less oblique, rounded cone without calyptra.

In the plankton of Ndawalene River (No. 28), stream near Port St. Johns (No. 50).

The present specimens differ a little from the original *O. chalybea* Mertens in the peculiar appearance of the apical cells, whose variation in form is illustrated in fig. 10. A close comparison between Gomont's fig. 19 and my figs. shows that the apical cell of the original specimens is not quite so pointed. The curvature of the trichome appears only in the terminal cell, or in this and the subterminal cell. This characteristic feature is found also in Gomont's fig. 19.

Distr. in Africa: North Africa, Algeria (C. Sauvageau); Cameroun (O. Nordstedt); **Brit. East Af.** Ruwenzori (according to P. Frémy), Mohasi Lake (E. Lemmermann); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich).

18. *Oscillatoria terebriformis* Ag. var. *tenera* n. var.—**(Fig. 11.)**

Trichomes 3–3·5 μ broad, of an intense blue-green colour, more or less distinctly spirally curved at the extremities, not constricted at the septa, which are mostly indistinct and without granules; cells in the middle of the trichome 1·5–2·5 μ long, terminal cell 3–5 μ long; contents homogeneous.

In Brakpans (No. 35).

The type is recorded from thermal and sulphur springs, so that it thrives in water at a high temperature and rich in inorganic compounds. The new variety was found under ecological conditions which are not so extreme, even though we are concerned with a sub-tropical sheet of water with an occasional high content of mineral salts.

The variety differs from the type in its thinner trichomes and in the shape and length of the terminal cells (*cf.* M. Gomont, 1893, p. 254. t. 7, fig. 24). The type has been found in Algeria (C. Sauvageau) and in the Azores (K. Bohlin).

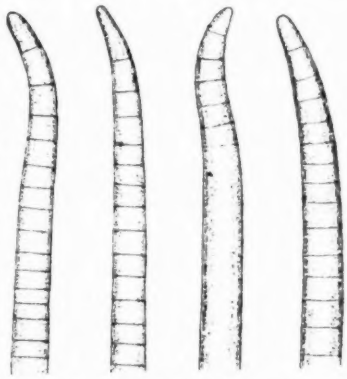


FIG. 11.—*Oscillatoria terebriformis* Ag. var. *tenera* n. var. × 1800.

19. *Lyngbya limnetica* Lemmermann, 1898, p. 154.

In the plankton of Brakpan (No. 1); Vereeniging waterworks (No. 41).

Distr. in Africa: North Africa, Algeria (according to P. Frémy); **French Equatorial Africa,** Gaboon (P. Frémy); **Brit. East Af.** Mohasi Lake (E. Lemmermann), Tanganyika (G. S. West), Victoria Nyanza (C. H. Ostenfeld).

20. *Plectonema Dangeardii* Frémy, 1930, p. 175, fig. 148.—**(Fig. 12.)**

Filaments almost straight, 2·5 μ thick; false branches frequent, solitary, of the same thickness as the main filaments; sheaths very thin and colourless; cells 1·5 μ broad and 4·5–10 μ long, 3–7 times as long as broad, pale blue-green, nearly colourless; cell-contents homogeneous, without granules at the septa; terminal cell rounded, without calyptra.

In Brakpan (No. 5).

Although the false branches in *P. Dangeardii*, according to Frémy, mostly occur in pairs, the present specimens correspond so closely to Frémy's diagnosis and figure that I have no doubts as to the identity. The species was found on a *Zygnema* filament in the plankton from Brakpan (No. 5).

Distr. in Africa: French Equatorial Africa, Gaboon (P. Frémy).

21. *Microcoleus Hospita* Hansg. var. *elongatus* n. var.—**(Fig. 13.)**

Filaments 4–13 μ broad, living in the thallus of *Calothrix inserta* n. sp.; 1–5 (generally 4) trichomes in each sheath, 1 μ broad; cells 2–5 times as long as broad, pale blue-green, with homogeneous contents; terminal cell long, conical, with rounded apex, without calyptra.

On *Potamogeton pectinatus*, Barberspan (No. 40).

The cells of the type are 1–2·5 times as long as broad according to Hansgirg (1890, p. 15), and the variety differs in having relatively longer cells. I examined No. 696 in Wittrock et Nordstedt, *Algae exsiccatae*, fasc. 14, in order to ascertain whether the present Cyanophycea could be identical with *M. tenerrimus* Gomont; the latter was, however, easily distinguished from *M. Hospita* Hansgirg by the long, subulate apices of the trichomes.

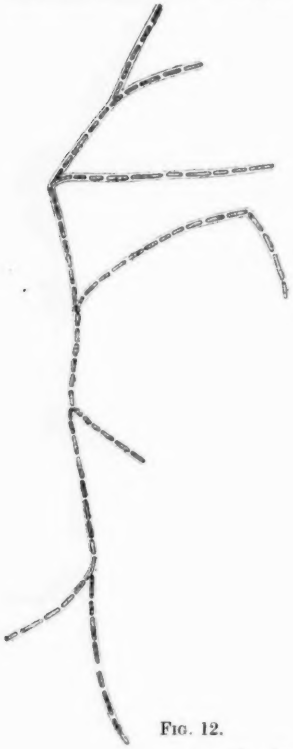


FIG. 12.

FIG. 13.

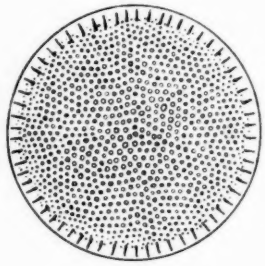


FIG. 14.

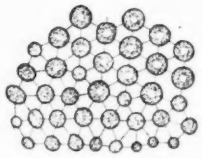


FIG. 15.

FIG. 12.—*Plectonema Dangeardii* Frémy. × 400.
FIG. 13.—*Microcoleus Hospita* Hansg. var. *elongatus* n. var. × 1440.
FIG. 14.—*Coscinodiscus incomptus*, n. sp. × 1560.
FIG. 15.—The same, part of the structure of the valve. × 6500.

DIATOMACEAE

COSCINODISCINAE

22. *Cyclotella Meneghiniana* Kg.; Fr. Hustedt, 1928, p. 341, fig. 174.

Individuals varying much in size (diameter 19–43 μ), as was also noted by Fritsch and Rich in individuals from Griqualand West, which measured 14-35 μ in diameter (1929, p. 94).

In the plankton of Brakpan (Nos. 1 and 5).

Distr. in Africa: North Africa, Egypt (J. Brunnthaler); Dahomey (Fr. Hustedt); **Brit. East. Af.** (G. Hieronymus), Victoria Nyanza (C. H. Ostenfeld), Nyasa (O. Müller, G. S. West), Country surrounding Nyasa, Malomba Lake, Rukwa Lake, Ngozi Lake (O. Müller); near Zambesi River (H. Schinz, N. Wille); **S. Africa,** Griqualand West, Natal (F. E. Fritsch and F. Rich), Little Namaqualand (G. S. West), Cape Colony (G. S. West), Transvaal (G. Huber-Pestalozzi).

23. *Coscinodiscus incomptus* n. sp.

(Syn.: *Coscinodiscus excentricus* Fritsch et Rich (non Ehrb.) 1929, p. 94, fig. 1)—**(Figs. 14–15.)**

Cells disc-shaped, 8–11 μ long, with almost flat, very slightly convex or concave valves, 23–28 μ in diameter. Valve-face covered with more or less rounded areolations, which decrease in size towards the margin, but not evenly,

since some very small areolations may be found among the larger ones not far from the centre of the valve; largest areolations 0·5 μ in diameter. Near the centre of the valve there are 13 areolations in 10 μ, at the margin 16 in 10 μ. The arrangement is very irregular. Radial rows of areolations are generally indistinct, a row from the centre generally dividing into two or three rows in its course. The tangential rows are only distinct at the margin of the valve, being concave towards the outside, but often bent abruptly; several systems of tangential rows are present. Spirally running rows are also very indistinct. The small areolations scattered among the larger ones mark the termination of one or more rows of areolations. These small areolations are surrounded by four or (generally) five large ones, while a large areolation is mostly surrounded by six others, six or seven when adjacent to the small areolations. In a strongly refractive medium a very thin line is seen to pass from each areolation to each of the surrounding ones; further, the internal openings of the larger chambers are seen (see fig. 15). At the point of curvature of the valve-face a circle of tiny spines are found, from 9–12 in 10 μ. In each cell there are about a score of small, disc-shaped chromatophores; nucleus central.

In the plankton of Barberspan (Nos. 9–10), Rietkuil (No. 21); on *Potamogeton pectinatus* in Barberspan (No. 40).

The great abundance of this species in sample No. 40 seems to show that it is a littoral and not a genuine plankton form; in the samples from the other two localities it was extremely rare. It was found at a temperature of 23·5° and at pH-values of 7·2 and 9·1. It is rather closely allied to *C. radiatus* Ehrb. (Fr. Hustedt, 1928, p. 420, fig. 225), which also has some small areolations scattered among the larger ones near the centre of the valve, and, like the areolation rows of the present species, those of *C. radiatus* are bent abruptly at the point where they pass through these small areolations. The structure of the areolations is obviously very nearly the same in the two species. *C. radiatus* Ehrb. is, however, a marine form, which reaches greater dimensions (30–180 μ), and has a much coarser structure of the valves than *C. incomptus*; further, there are no intramarginal spines, and the areolations do not decrease in size towards the margin.

The reasons why I regard Fritsch and Rich's *C. excentricus* as identical with *C. incomptus* and not with *C. excentricus* Ehrb. are as follows. Their specimens are 21–25 μ in diameter; *C. excentricus* Ehrb. measures from 20–100 μ in diameter. The arrangement of the areolations is, according to the description and figure, more or less indistinct; according to the figure there are 12 areolations in 10 μ in the middle of the valve and about 14 in 10 μ at the margin; on the valves of *C. excentricus* Ehrb. there are from 3–5 areolations in each 10 μ in the middle and from 5–9 in 10 μ at the margin. The intramarginal spines are placed at regular intervals and are all alike; in *C. excentricus* Ehrb. the intervals between the spines are unequal, and one of the spines is characteristically very thick and blunt (see Fr. Hustedt, 1928, fig. 201*a* above on the right, 201*b* above). According to the figure there are 9 or 10 spines in 10 μ, while *C. excentricus* Ehrb. has only 2–4 spines in 10 μ.

I compared *C. incomptus* with *C. excentricus* Ehrb. in Van Heurck's type collection, and this confirmed the view that *C. incomptus* differs greatly from the typical *C. excentricus* Ehrb.

It must be specially emphasised, however, that the structure of the valves is quite different in the two species. While the large polygonal areolations in *C. excentricus* Ehrb. are arranged in several linear systems crossing each other, it is impossible to recognise such an arrangement in the case of the small rounded areolations of *C. incomptus*. If one attempts to draw straight lines through the areolations, one is sooner or later checked by the minute areolations mentioned in the diagnosis of the species; and if the line is to be carried on, it must necessarily be bent abruptly.

It proved very difficult to produce an exact drawing of a Coscinodiscus of such small dimensions, and the following special method was used. The valves, mounted in a specially strongly refractive medium ("the yellow medium," refractive index ab. 2·4, see E. Strasburger: Das botanische Practicum, 1921, pp. 442–443), were photographed by means of a Zeiss Phocu apparatus. As the picture proved to be too small (magnified 450 times), it was magnified to 1560 times on silver bromide paper. After complete drying, areolations, spines, and outlines were drawn in in waterproof black ink and the whole afterwards placed in a potassium permanganate solution containing a little sulphuric acid. If the photograph thus thinned is finally put into an acetic fixing-bath, the dark drawing in black ink is seen quite clearly on a clean, white background. Drawings produced in this way are much clearer in reproduction than ordinary photographs, and have the advantage over other figures in being absolutely objective, provided, of course, that the drawing is accurate. The only difficulty of the method lies in drawing with black ink on photographic paper.

Distr. in Africa: South Africa, Griqualand West (F. E. Fritsch and F. Rich).

MELOSIRINAE

24. *Melosira ambigua* O. Müller subsp. *variata* O. Müller, 1904, p. 283, t. 3, fig. 4.

This species was the dominant form in the plankton of Florida Lake (Nos. 23–24).

Distr. in Africa: Brit. East Af., Nyasa, Malomba Lake, Ikapo Lake (O. Müller), Victoria Nyanza (C. H. Ostenfeld J. Woloszynska), Mohasi Lake (E. Lemmermann); Azores (W. Krieger).

25. *Melosira granulata* Ralfs; O. Müller, 1904, pp. 267, 275, t. 3, figs. 6–7.

In the plankton of Vaal River, Vereeniging (Nos. 25–26), Barberspan (No. 10).

Distr. in Africa: North Africa, Egypt (R. Muschler, G. S. West), El Kab (O. Müller); **Brit. East Af.**, Victoria Nyanza (O. Müller, C. H. Ostenfeld, J. Virieux, G. S. West), Nyasa (O. Müller, G. S. West), Albert Nyanza (G. S. West), Mohasi Lake (E. Lemmermann); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich), Rhodesia, Transvaal (G. Huber-Pestalozzi).

Var. *angustissima* O. Müller, 1899, p. 315, t. 12, fig. 28; 1904, pp. 270, 285, t. 4, fig. 12.

This cosmopolitan variety seems to be generally distributed in the Transvaal lakes. It obviously does not thrive very well in the ponds (the natural pans), as it has only been found in very small quantities in the plankton from Brakpan and Barberspan. It is surprising in its periodicity, inasmuch as it reaches a very great development both in February and July (cp. No. 21 with Nos. 25–26 in the table on p. 106). This is perhaps to be explained by the fact

that the temperature of the larger bodies of water in Transvaal does not fall under the temperature optimum of this form ; the day temperature is often rather high in winter.

In the plankton of Brakpan (Nos. 4–5), Barberspan (No. 10), Rietkuil (No. 21), Vaal River Dam (Nos. 25–26) ; in mud from Vereeniging waterworks (No. 41).

Distr. in Africa : North Africa. Egypt (J. Brunnthaler, R. Muschler), El Kab (O. Müller) ; Dahomey (F. Hustedt) ; **Brit. East Af.,** Victoria Nyanza (G. S. West, J. Woloszynska), Nyasa (G. S. West), Mohasi Lake (E. Lemmermann), Rukwa Lake (O. Müller) ; **S. Africa,** Transvaal, Orange Free State, Cape Colony (G. Huber-Pestalozzi).

26. *Melosira varians* Ag. ; F. Hustedt, 1927, p. 240, fig. 100.

In the plankton of Ndawalene River (No. 28), Vaal River Dam (No. 25).

Distr. in Africa : North Africa, Egypt (J. Brunnthaler, G. S. West), Dahomey (F. Hustedt) ; **French Equatorial Africa.** Ubangi (P. Frémy) ; **Brit. East Af.,** Country surrounding Nyasa (O. Müller) ; **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich), Cape Colony (F. E. Fritsch) ; Azores (W. Farlow) ; Madeira (R. Schodduyn).

TABELLARIEAE

27. *Tabellaria flocculosa* Kg. ; H. van Heurck, 1884, t. 52, figs. 10–12.

To judge from the records this species, which is so widely distributed in Northern Europe, seems to be very rare in Africa. Breadth of cells 9 μ, length 24 μ ; 19 or 20 transverse lines in 10 μ.

In the plankton of Florida Lake (Nos. 23–24).

Distr. in Africa : Dahomey (F. Hustedt) ; Angola (W. and G. S. West) ; Azores (W. Krieger).

NITZSCHIEAE

28. *Nitzschia longissima* Ralfs var. *closterium* W. Smith ; (?) H. van Heurck, 1884, t. 70, figs. 7–8.—**(Fig. 16.)**

In spite of a thorough search only one specimen was found ; it measured 5 μ in breadth and 85 μ in length ; more detailed determination proved impossible.

In the plankton of Barberspan (No. 10).

Distr. in Africa : not recorded in the literature.

SURIRELLEAE

29. *Surirella ovalis* Bréb. var. *apiculata* O. Müller, 1903, p. 36, t. 2, fig. 10.

This variety may have more or less protracted poles (cp. O. Müller's fig. 10 with fig. 11, *ibid.*). Fritsch and Rich (1929, p. 122, fig. 11A) have figured a form very closely related to var. *apiculata* Müller, at any rate more closely than to *S. ovalis* Bréb. in H. van Heurck, 1884, t. 73, figs. 2–3.

On *Potamogeton pectinatus* in Barberspan (No. 40).

Distr. in Africa : Brit. East Af., Nyasaland (O. Müller) ; **South Africa,** Griqualand West (F. E. Fritsch and F. Rich). The type : **North Africa,** Cyrenaica (G. B. De Toni and A. Forti), Egypt (J. Brunnthaler, R. Muschler, G. S. West), El Kab (O. Müller) ; **Brit. East Af.** (W. and G. S. West) ; **South Africa,** Transvaal, Orange Free State (G. Huber-Pestalozzi), Natal (F. E. Fritsch and F. Rich), Little Namaqualand (G. S. West), Cape Colony (G. S. West, F. E. Fritsch) ; Madeira (R. Schodduyn).

FLAGELLATAE

EUCHROMULINACEAE

30. *Chrysococcus minutus* (Fritsch) mihi.

(Syn. : *Trachelomonas volvocina* Ehrb. f. *minuta* Fritsch, 1918, p. 603, fig. 43 F ; K. Berg and G. Nygaard, 1929, p. 292, t. 3, fig. 42).—**(Fig. 17.)**

In the work of K. Berg and G. Nygaard on the plankton in Frederiksborg Slotsö, a very small form of *Trachelomonas volvocina* Ehrb., f. *minuta* Fritsch was recorded. At that time I was unable to decide that this form was not a *Trachelomonas*, but a *Chrysococcus*, because I had not studied it alive. Later I often found it in living plankton from Danish ponds, sometimes in great quantities. The diagnosis below is thus based on living material.

Cells 5–10 μ in diameter, generally spherical, rarely broadly elliptical ; valve structureless, more or less intensely brown-coloured, with two minute verrucae on each side of the cilial opening and with a pore in the opposite pole of the valve ; one rather large cup-shaped, brown chromatophore ; a linear, distinct stigma near the cilial aperture ; the cilium ab. twice the length of the cell.

In the plankton of Teglgaard Sö, Denmark.

As stated by Fritsch (1918, p. 603), it is " very difficult to arrive at any conclusion as to the exact nature of the pore " of the test. The cilial aperture is also not distinct, but the two minute verrucae can generally be seen in fully developed specimens by means of immersion objectives.

Among algae from Vereeniging waterworks (No. 41).

Distr. in Africa : S. Africa, Cape Colony (F. E. Fritsch).

MALLOMONADACEAE

31. *Mallomonas alpina* Pascher et Ruttner; A. Pascher, 1913, p. 36, fig. 58*a*.

The arrangement of the scales and their peculiar appearance correspond closely to Ruttner's drawing (*loc. cit.*, fig. 58*a*). Owing to the transport of the samples to Europe most individuals were without bristles, but in the two specimens with bristles found, these were arranged as shown in fig. 58*a*. A large number of detached bristles were observed in the sample, and in most cases the scale still clung to the bristle. Pascher states (*loc. cit.*): "In der typischen Form bislang nur aus Lunz." There is, however, hardly any doubt that the African specimens are typical *Mallomonas alpina* Pasch. et Ruttn.

In the plankton of Florida Lake (No. 24).

Distr. in Africa: not recorded in the literature.

Some few indeterminable individuals of a *Mallomonas* were found in the plankton of Rietkuil (No. 21).

Fig. 16.

Fig. 17.

Fig. 19.

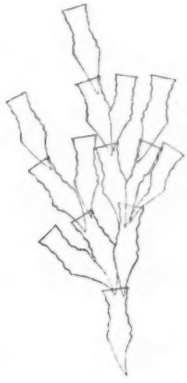


Fig. 18.

Fig. 16.—*Nitzschia longissima* Ralfs var. *closterium* Smith? × 800.
Fig. 17.—*Chrysococcus minutus* (Fritsch) mihi. × 755.
Fig. 18.—*Dinobryon divergens* Imhof. × 400.
Fig. 19.—*Phacus acuminata* Stokes. × 755.

LEPOCHROMONADINEAE

32. *Dinobryon divergens* Imhof; A. Pascher, 1913, p. 79. fig. 127*a–d*; E. Lemmermann, 1910, pp. 468, 451, figs. 6–8 (*Dinobryon cylindricum* Imhof var. *divergens* (Imhof) Lemmermann).—**(Fig. 18.)**

The colonies present correspond very well to Pascher's diagnosis (*loc. cit.*). The individual envelopes were 30–38 μ long (of which 15–17 μ belong to the terminal cone), and 8·5–10 μ broad. The colonies were mostly small, no doubt because they had partly broken up in the transport to Europe. The few well-preserved colonies (as shown in fig. 18) were rather dense, like those of the vernal form in the lakes of Northern Europe (see C. Wesenberg-Lund, 1904, p. 114 ff., E. Lemmermann, *loc. cit.*, fig. 7). The specimens differ from the drawings of the type given by Pascher (*loc. cit.*) in the front part of the envelopes having slightly undulated walls, which is a characteristic feature of var. *Schauinslandi* Lemm. The envelopes of this variety are, however, not undulated at the commencement of the terminal cone, as in those of the present form.

Whether the species shows a distinct seasonal variation in the lakes of the Transvaal cannot be decided from the present material. The fairly dense colonies were, however, found in the two vernal samples from Florida Lake, so this, at any rate, does not exclude the possibility of a seasonal variation for this species in the lakes of Transvaal. If we connect the seasonal variation primarily with changes in the temperature of the lake, the limits of the temperature-interval within which a seasonal variation may occur, are no doubt different from those in the North European lakes.

Regarding the periodicity of the species, see p. 105. The great rarity of *Dinobryon* in Africa has been mentioned on p. 112.

In the plankton of Florida Lake (Nos. 23–24).

Distr. in Africa: not recorded in the literature.

EUGLENACEAE

33. *Phacus acuminata* Stokes; E. Lemmermann, 1913, p. 138, fig. 233.—**(Fig. 19.)**

The only specimen found had many paramylon-grains in the apex and a very large paramylon-grain (?) in the base of the cell; the latter was not as markedly refractive as the small ones. Otherwise the characters corresponded very well to the diagnosis cited. Length 21 μ, breadth 18 μ.

Among algae from Rietfontein (No. 39).

Distr. in Africa: not recorded in the literature.

34. *Phacus pleuronectes* Duj.; E. Lemmermann, 1913, p. 138, fig. 236.

In the plankton of Florida Lake (No. 24).

Distr. in Africa: Brit. East Af. (G. Hieronymus), Albert Nyanza (G. S. West); **S. Africa,** Transvaal, Orange Free State (G. Huber-Pestalozzi), Cape Colony (F. E. Fritsch and E. Stephens, G. Huber-Pestalozzi); Madeira (R. Schodduyn).

Phacus anomala, described by Fritsch and Rich from Griqualand West (1929, p. 73, fig. 24 *H–N*), is probably identical with *P. alata* Klebs var. *latviensis* (Skuja) Skvortzow (1928, p. 112) (Syn.: *P. alata* Skuja (non Klebs) 1926, p. 40, Abb. 2, fig. 2 *a–d*). I have studied this form alive in a very much contaminated pond in Denmark.

35. *Trachelomonas volvocina* Ehrb.; E. Lemmermann, 1913, p. 145, fig. 246.

This flagellate is typically ubiquitous.

Among algae from Rietfontein (No. 39), Vereeniging waterworks (No. 41).

Distr. in Africa: Brit. East Af. (G. Hieronymus), Mohasi Lake (E. Lemmermann); **S. Africa,** Griqualand West, Natal (F. E. Fritsch and F. Rich), Transvaal, Orange Free State (G. Huber-Pestalozzi), Cape Colony (F. E. Fritsch and E. Stephens, G. Huber-Pestalozzi).

36. *Trachelomonas hispida* Stein; E. Lemmermann, 1913, p. 149, fig. 272.

In the sample from Rietfontein (No. 39) there occurred a few specimens corresponding closely to K. Berg and G. Nygaard, 1929. t. 5, fig. 7, left.

In the plankton of Vaal River Dam (No. 26), Mtakati River (No. 32); among algae from Vereeniging waterworks (No. 41).

Distr. in Africa: Brit. East Af. (G. Hieronymus); **S. Africa,** Transvaal, Orange Free State (G. Huber-Pestalozzi), Natal (F. E. Fritsch and F. Rich), Cape Colony (F. E. Fritsch and E. Stephens); Madagascar (F. E. Fritsch).

Var. *crenulatocollis* Lemmermann, 1913, p. 150.

Among algae from Rietfontein (No. 39).

Distr. in Africa: not recorded in the literature.

DINOFLAGELLATAE

PERIDINIACEAE

37. *Peridinium bipes* Stein var. *occultatum* Lindemann, 1918, ii, p. 132, figs. 30–31, 35.

The plates on the epivalve of the specimens correspond exactly to fig. 30, *loc. cit.* The two antapical plates are very unequal in size; the difference between them may be greater than shown in Lindemann's fig. 31. E. Lindemann found few specimens of var. *occultatum* in typical *P. bipes*-populations. In Florida Lake, however, the population consisted exclusively of specimens of var. *occultatum* Lindem., not a single specimen with greatly developed flanges being observed.

On August 28, 1928 (winter) the species was very rare in the plankton from Florida Lake, but on September 10, 1928, it was common. Unfortunately, there were no further plankton samples from the spring months of 1928, so that it is impossible to decide whether the species is a winter form or an early vernal form, as in Germany (E. Lindemann, *loc. cit.*, p. 187). But the above dates are in favour of the latter possibility.

In the plankton of Florida Lake (Nos. 23–24).

Distr. in Africa: not recorded in the literature.*

In what follows I shall revise some species of *Peridinium* described by me in 1925 and 1926, from the Gatun Lake, Panama, and Ohoitiel Lake in the Key Islands near New Guinea, respectively. When the species were described, I was not familiar with E. Lindemann's works on freshwater Peridiniae (see literature).

1. *Peridinium gatunense* Nygaard (C. H. Ostenfeld and G. Nygaard, 1925, p. 10, figs. 5–10) = *P. cinctum* Ehrb. var. *gatunense* mihi, characterised by its spherical cells, which are hardly flattened at all, and by the fact that the longitudinal furrow is not continued on to the epivalve.

2. *Peridinium marchicum* Lemm. var. *keyense* Nygaard (1926, p. 209, t. 3, fig. 29*a–h*) = *P. munusculum* Lindem. f. *spiniferum* Lindemann (1918, p. 143, figs. 71–74).

3. *Peridinium Cunningtonii* Lemm. var. *quinquecuspidatum* Nygaard (1926, p. 208, t. 3, fig. 28*a–f*) remains; it is characterised by the five large spines on the hypovalve, one of which is placed at the antapical pole.

4. *Peridinium keyense* Nygaard and its var. *gonyaulacoides* Nygaard (1926, p. 208, t. 4, figs. 32*a–f* and 33*a–f*) also remain; they differ from *P. tabulatum* Cl. et Lachm., to which they seem most closely related, by the arrangement of the plates on the epivalve, and by the appearance of the longitudinal furrows.

5. *Gonyaulax Jensenii* Nygaard (1926, p. 206, t. 4, fig. 34*a–h*) = *Peridinium Jensenii* mihi, very well characterised by two small, dorsal plates on the epivalve.

---

* See, however, paper by Miss Rich on S. African Phytoplankton in this vol.—E. L. S.

CHLOROPHYCEAE

The species have been arranged according to the system used by H. Printz in his important work: "Chlorophyceae," in A. Engler und K. Prantl's Die natürlichen Pflanzenfamilien, 2. Auflage.

VOLVOCACEAE

38. *Eudorina elegans* Ehrb.; A. Pascher, 1927, p. 440, figs. 394–401.

This cosmopolitan species seems to be generally distributed in Transvaal. It is a noteworthy fact that it occurs in the natural pans with their occasional high content of mineral salts.

In the plankton of Brakpan (Nos. 3 and 5), Pan near Breyton (No. 8), Vaal River Dam (No. 25), Lukalla River (No. 31).

Distr. in Africa: North Africa, Algeria (F. Debray, Giard), Egypt (J. Brunnthaler); **Brit. East Af.** (O. Borge), Victoria Nyanza (C. H. Ostenfeld, J. Woloszynska), Nyasa and several places in the neighbourhood of the lake (W. Schmidle); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich), Transvaal (F. Huber-Pestalozzi), Orange Free State, Cape Colony (F. E. Fritsch); Azores (K. Bohlin).

39. *Volvox Rousseletii* G. S. West, 1910, p. 101, t. 3, figs. 1–7.

This large species was described by G. S. West from material from a large pool in Rhodesia. The colonies in the present samples measure up to 1220 μ in diameter; the smallest colony (a daughter-colony just detached) was 180 μ in diameter. Already, when no bigger than 580 μ, the colonies may have formed eight small daughter-colonies. The cells are 4–6 μ broad, round, and almost contiguous in the very young colonies, more or less angular, sometimes stellate in adult colonies, where the intervening spaces are very nearly equal to the breadth of the cells; the number of cells in a colony 1220 μ in diameter was calculated at 24,750! Remains of protoplasmatic processes were visible between the cells.

The number of daughter-colonies varied somewhat from locality to locality. In Rietfontein the only colony seen had 8, while in Brakpan two colonies had 4 daughter-colonies each, three had 6 each, and two had 8 each. In "Brakpan, small pan near station" two colonies had 10 daughter-colonies each, two had 12 each, two had 14 each, and one had 16. Perhaps several forms are included in *Volvox Rousseletii* West, but this can only be decided by the examination of living and reproductive material from the localities mentioned.

The three localities listed below all belong to the natural pans which dry up in winter. Here *V. Rousseletii* West obviously finds good life conditions. The vegetative colonies undoubtedly cannot stand drying in winter, and it is highly probable that the species survives the unfavourable season exclusively as resting-spores. These have been described and figured by G. S. West, 1918.

As several plankton samples were taken from Brakpan in the autumn of 1928, some information can be given as to the biology of the species. It was not seen on September 7, 1927. At the beginning of February 1928 Brakpan was filled with rain-water. In the sample from February 19 the species was not yet present, but several specimens were observed in the samples from March 11 and April 15, especially in the former. Thus the species had a distinct autumnal maximum in the month of March. On May 6 several specimens were collected in "Brakpan, small pan near station."

Curiously enough, C. F. Rousselet collected *V. Rousseletii* West in ***September*** 1905, in a pool in Rhodesia (probably a natural pan).*

In the plankton of Brakpan (Nos. 4–5), Brakpan, small pan near station (No. 6), Rietfontein (No. 12).

Distr. in Africa: S. Africa, Rhodesia (G. S. West).

TETRASPORACEAE

40. *Gloeococcus Schroeteri* (Chodat) Lemmermann, 1915, p. 31; R. Chodat, 1897, p. 292, t. 9 (*Sphaerocystis Schroeteri* Chod).

In the plankton of Vaal River Dam (No. 25), among algae from Vereeniging waterworks (No. 41).

Distr. in Africa: Brit. East Af., Victoria Nyanza (J. Virieux), Tanganyika (G. S. West); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich), Transvaal (G. Huber-Pestalozzi), Cape Colony (F. E. Fritsch, ? G. Huber-Pestalozzi).

CHLOROCOCCACEAE

41. *Characium limneticum* Lemm.; J. Brunnthaler, 1915, p. 84, fig. 41.

In the plankton of Brakpan (No. 3).

Distr. in Africa: not recorded in the literature.

HYDRODICTYACEAE

42. *Pediastrum simplex* Meyen var. *clathratum* (Schröter); G. S. West, 1907, pp. 134–135, t. 2, figs. 17–18; t. 3, fig. 16.

In the plankton of Rietkuil (No. 21).

Distr. in Africa: Brit. East Af., Victoria Nyanza (C. H. Ostenfeld, W. Schmidle, G. S. West, J. Virieux, J. Woloszynska), Nyasa (W. Schmidle, G. S. West), Malomba Lake (W. Schmidle); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich), Transvaal (G. Huber-Pestalozzi); Madagascar (W. and G. S. West).

---

* Rousselet's pool is a small pan which dries up partially or completely in winter, and still produces *V. Rousseletii*. —E. L. S.

43. *Pediastrum duplex* Meyen var. *clathratum* A. Br., 1855, p. 93; J. Brunnthaler, 1915, p. 95, fig. 57*d*.

In the plankton of Florida Lake (No. 24).

Distr. in Africa: Brit. East Af. (O. Borge), Victoria Nyanza (C. H. Ostenfeld, W. Schmidle, G. S. West, J. Virieux, J. Woloszynska), Tanganyika (G. S. West), Nyasa, Malomba Lake (W. Schmidle), Mohasi Lake (E. Lemmermann); **S. Africa,** Transvaal (G. Huber-Pestalozzi); Madagascar (W. and G. S. West).

Var. *reticulatum* Lagerheim, 1882, p. 56, t. 2, fig. 1 (Syn.: *Pediastrum duplex* Meyen var. *clathratum* Woloszynska (non A. Braun), 1912, p. 662, fig. 2 *A*, *B*, *C*).

In the plankton of Brakpan (Nos. 3 and 5), Vaal River-dam (Nos. 25–26).

Distr. in Africa: Brit. East Af. (O. Borge), Victoria Nyanza (W. Schmidle, G. S. West, J. Virieux), Tanganyika, Albert Nyanza (G. S. West); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich), Transvaal (G. Huber-Pestalozzi), Cape Colony (F. E. Fritsch, G. Huber-Pestalozzi); Azores (W. Krieger).

Var. *asperum* A. Braun, 1855, t. 2, figs. 15–24; J. Brunnthaler, 1915, p. 96, fig. 57*m*.

Among algae from Zambesi River (No. 51).

Distr. in Africa: Brit. East Af. (O. Borge); Madagascar (W. and G. S. West).

Var. *brachylobum* A. Braun, 1855, t. 2, fig. 25; J. Woloszynska, 1912, p. 662, fig. 2 *F–G*; J. Brunnthaler, 1915, p. 96, fig. 57*o*.

Among algae from Alberton (No. 42).

Distr. in Africa: not recorded in the literature.

44. *Pediastrum constrictum* Hassal; J. Brunnthaler, 1915, p. 100, fig. 60 *F*.

Among algae from Zambesi River (No. 51).

Distr. in Africa: Madagascar (W. and G. S. West).

45. *Pediastrum Boryanum* Menegh.; J. Brunnthaler, 1915, p. 100, fig. 61*a*.

In the plankton of Barberspan (Nos. 9–10), in scum from Geduld Dam (No. 45).

Distr. in Africa: North Africa, Algeria (F. Debray), Cyrenaica (G. B. De Toni and A. Forti); Abyssinia (G. B. De Toni); **Brit. East Af.** (O. Borge, W. and G. S. West), Victoria Nyanza (G. S. West, J. Virieux), Tanganyika, Albert Nyanza (G. S. West), Nyasa (W. Schmidle, G. S. West); **S. Africa,** Transvaal (G. Huber-Pestalozzi), Cape Colony (G. S. West, F. E. Fritsch, O. Nordstedt); Azores (W. Archer, K. Bohlin, W. Farlow).

46. *Hydrodictyon reticulatum* Lagerheim; H. Printz, 1927, p. 112, fig. 67.

In the plankton of Ndawalene River (No. 28), stream near Port St. Johns (No. 50).

Distr. in Africa: North Africa, Algeria (F. Debray, C. Sauvageau); Abyssinia (G. B. De Toni).

In sample No. 39 from Rietfontein there were some pale bodies, about 1·5 mm. broad and 6–12 mm. long, with rounded extremities. If these belong to an alga at all, I think it is *Hydrodictyon indicum* Iyengar.*

OOCYSTACEAE

47. *Lagerheimia subsalsa* Lemm., 1898, p. 310; Forschungsb. Biol. Stat. Plön., 6, 1898, t. 5, figs. 2–6.—**(Fig. 20.)**

The specimens correspond very well to Lemmermann's diagnosis. The cells were 13–15 μ long, 6·5–9 μ broad, the bristles were 8–13 μ long and were disposed in numbers of two or three at each apex of the cell. One or two pyrenoids in each cell.

In the plankton of Barberspan (Nos. 9–10).

Distr. in Africa: Brit. East Af., Victoria Nyanza (J. Virieux), Tanganyika (G. S. West).

48. *Oocystis crassa* Wittrock var. *Marssonii* Printz, 1913, p. 176, t. 4, figs. 16–17.—**(Fig. 21.)**

Cells small, ovoid, 1·4–2 times as long as broad, subacute or broadly rounded at the extremities, which are frequently slightly incrassate. One or two chromatophores with pyrenoid were seen in some few cells. Cells rarely solitary, mostly 2–4 (very rarely 8) enclosed in the thin-walled mother-cell membrane, which is slightly thickened at the poles. Length of cells 8–15 μ, breadth 5–9·5 μ; length of colonies 22–29 μ, breadth 13–21 μ.

The above diagnosis applies to the specimens from Barberspan. In Brakpan, on September 7, 1927, great numbers of Oocystis cells were found, which, I think, should also be referred to *O. crassa* var. *Marssonii*. Their characters were: Cells small, ovoid, 1·6–1·8 times as long as broad, more or less rounded and slightly incrassate at the extremities. Generally two pyrenoids in each cell; only the largest cells, which were about to divide, had four pyrenoids. Cells mostly solitary, rarely forming two-celled colonies. Length of cells 8·5–14 μ, breadth 5–9 μ.

The latter form reached a great development in Brakpan in September 1927; in the autumn months of 1928 (February, March, April) it was not observed in any of the samples. The species was found only in the plankton from the natural pans.

In the plankton of Brakpan (No. 1) and Barberspan (Nos. 9–10).

Distr. in Africa: S. Africa, Natal (F. E. Fritsch and F. Rich). The type is recorded from **Brit. East Af.** by G. Hieronymus.

49. *Tetraedron minimum* Hansg.; J. Brunnthaler, 1915, p. 147; O. Borge, 1921, p. 30, t. 2, figs. 29–33.

In the plankton of Brakpan (No. 1) and Barberspan (No. 9).

---

* These are undoubtedly mature and separated coenocytes of *H. indicum*, which occurs in this pan. When preserved in formalin or alcohol they have just the appearance here described.—E. L. S.

Distr. in Africa: Abyssinia (G. Lagerheim); **Brit. East Af.** (O. Borge), Victoria Nyanza (J. Woloszynska), Nyasa, Tanganyika, Albert Nyanza (G. S. West), Mohasi Lake (E. Lemmermann); Angola (W. and G. S. West); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich), Little Namaqualand (G. S. West), Cape Colony (F. E. Fritsch and E. Stephens, G. Huber-Pestalozzi, G. S. West); Azores (K. Bohlin, W. Krieger); Madagascar (W. and G. S. West).

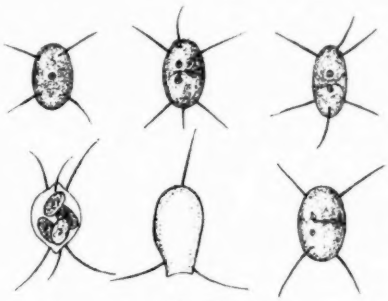


FIG. 20.

FIG. 21.

FIG. 20.—*Lagerheimia subsalsa* Lemm. ×800. FIG. 21.—*Oocystis crassa* Wittr. var. *Marssonii* Printz. ×640.

COELASTRACEAE

50. *Dictyosphaerium pulchellum* Wood, 1874, p. 84, t. 10, fig. 4.
In the plankton of Florida Lake (No. 24).
Distr. in Africa: Abyssinia (G. Lagerheim); **Brit. East Af.** (O. Borge, G. Hieronymus), Victoria Nyanza (C. H. Ostenfeld, G. S. West, J. Virieux, J. Woloszynska), Nyasa and its surrounding country (G. S. West and W. Schmidle),

FIG. 22.

FIG. 23.

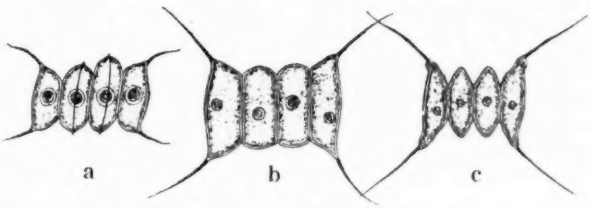


FIG. 24.

FIG. 22.—*Dictyosphaerium Ehrenbergianum* Näg. ×640. FIG. 23.—*Scenedesmus acutiformis* Schröder, *a*, a_1 (×800), *b* (×755). FIG. 24.—*a*, *Scenedesmus armatus* Chodat. *b*, *S. quadricauda* Chodat. *c*, *S. opoliensis* Richter. All ×800.

Tanganyika (G. S. West); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich), Orange Free State (G. Huber-Pestalozzi), Cape Colony (F. E. Fritsch and E. Stephens, G. Huber-Pestalozzi); Azores (K. Bohlin).

51. *Dictyosphaerium Ehrenbergianum* Nägeli, 1849, p. 74, t. 2 *E.*—**(Fig. 22.)**
Cells 8–9 μ long, 3·5–4 μ broad, the colony 32 μ broad.
In the plankton of Barberspan (Nos. 9–10).
Distr. in Africa: S. Africa, Cape Colony (F. E. Fritsch); Azores (W. Archer, K. Bohlin, W. Farlow).

52. *Scenedesmus acutiformis* Schröder, 1897, p. 45, t. 2, fig. 4; G. M. Smith, 1916, p. 456, t. 26, figs. 28–29; t. 29, figs. 84–89; R. Chodat, 1926, p. 198, fig. 95.—**(Fig. 23.)**

The specimens from Rietfontein, the cells of which were 16–21 μ long (inclusive of ridges) and 4–6·5 μ broad, are obviously typical. As will be seen from fig. 23*a*, there is no essential difference between the four cells of the coenobium. But in another coenobium observed in the sample No. 39 from Rietfontein the two outer cells were more lunate than the inner cells (cf. fig. 23*b*). The cells in this coenobium measured 19–20 μ in length (inclusive of ridges) and 4–5 μ in breadth.

In the plankton of Rietfontein (No. 14), among algae from Rietfontein (No. 39).

Distr. in Africa: Brit. East Af., Nyasa, Albert Nyanza (G. S. West); **S. Africa,** Cape Colony (W. Hodgetts).

53. *Scenedesmus armatus* Chodat var. *Chodatii* Smith, 1916, p. 461, t. 30, figs. 111–114.—**(Fig. 24a.)**

Length of cells 12–21 μ, breadth 4·5–10 μ.

S. armatus Chodat is a very variable species. Among its most important distinctive features may be mentioned the delicate ridges, which run longitudinally on the cell-wall.

Coenobia are sometimes found, the cells of which are without ridges, but which, as far as form and arrangement of the cells and form and number of the spines are concerned, are very similar to typical specimens. Coenobia are not infrequently found (fig. 24*a*) in which some of the cells have ridges, whilst the rest are without them (see also G. M. Smith, 1916, t. 30, fig. 114). Further, it is nearly always possible in rich material to find coenobia with accessory spines (see *e.g.* G. M. Smith, 1916, t. 30, fig. 119; Chodat, 1926, p. 204, fig. 107, *S. Woloszynskae* Chodat; Berg and Nygaard, 1929, t. 6, fig. 52; Fritsch and Rich, 1929, p. 31, fig. 5 *A–C*). The length of the terminal spines is also subject to considerable variations (see *e.g.* Fritsch and Rich, 1929, p. 31, fig. 5 *A–C*).

Fig. 25.

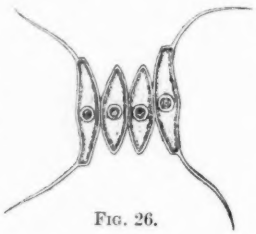


Fig. 26.

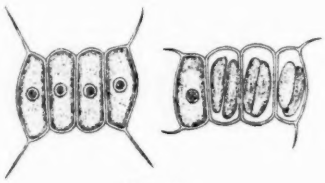


Fig. 27.

Fig. 25.—*Scenedesmus dimorphus* Kg.
Fig. 26.—*S. opoliensis* Richter.
Fig. 27.—*S. quadricauda* Bréb. var. *quadrispina* Smith. All × 725.

In the plankton of Brakpan (No. 1), Barberspan (Nos. 9–10), Lukalla River (No. 31, very abundant), Mtakati River (Nos. 32–33).

Distr. in Africa: Brit. East Af. (O. Borge); **S. Africa**, Griqualand West (F. E. Fritsch and F. Rich); Azores (W. Krieger).

Var. *subalternans* G. M. Smith, 1916, p. 461, t. 30, figs. 115–120.

Among algae from Vereeniging waterworks (No. 41).

Distr. in Africa: not recorded in the literature.

54. *Scenedesmus dimorphus* Kützing; G. M. Smith, 1916, p. 434, t. 25, fig. 8; t. 32, figs. 185–189; t. 33, figs. 190–195; R. Chodat, 1926, p. 128, fig. 20.—**(Fig. 25.)**

As the cells were arranged in one plane, I have—although the central cells of the coenobium were not always straight—identified the specimens with *S. dimorphus* Kg. and not with *S. falcatus* Chodat (see Chodat, 1926, p. 146, figs. 36–37; G. M. Smith, 1916, p. 437, t. 25, figs. 3–5). Cells 14–17 μ long, 2·5–3·5 μ broad.

In scum from Geduld Dam (No. 45).

Distr. in Africa: Brit. East Af. (O. Borge); **S. Africa,** Cape Colony (F. E. Fritsch, W. Hodgetts).

55. *Scenedesmus opoliensis* Richter; G. M. Smith, 1916, p. 481, t. 27, fig. 49; t. 32, figs. 181–184.—**(Figs. 24c and 26.)**

Length of cells 19–22 μ, breadth 5–5·5 μ for the specimens from Geduld Dam (fig. 26); the specimens from Barberspan measured 12–16 μ in length and 4·5–5 μ in breadth (fig. 24*c*).

In scum from Geduld Dam (No. 45); in the plankton of Barberspan (No. 10).

Distr. in Africa: Brit. East Af. (O. Borge), Tanganyika, Albert Nyanza (G. S. West); **S. Africa**, Cape Colony (G. Huber-Pestalozzi).

56. *Scenedesmus quadricauda* Bréb. var. *quadrispina* Smith, 1916, p. 479, t. 27, fig. 43; t. 31, figs. 167–170; (Syn: *S. quadrispina* Chodat, 1926, p. 230, fig. 134).—**(Fig. 27.)**

In this variety the spines are relatively shorter than in the type ($\frac{1}{5}$–$\frac{2}{3}$ of the length of the cell). Length of cells 16–19 μ, breadth 5–7 μ.

Fig. 24 shows three coenobia from the plankton of Barberspan. These coenobia represent morphologically intermediate forms. A number of species obviously occur in this locality with such great ranges of variation that

they partly overlap. Fig. 24*a* is *Scenedesmus armatus* Chodat var. *Chodati* Smith; fig. 24*c* I have identified with *S. opoliensis* Richter, and fig. 24*b* shows so close a correspondence with *S. quadricauda* (Bréb.) Chodat (1926, p. 229, fig. 133) that I do not hesitate to name it so. The cells of the latter measured 15–20 μ in length, 6·5–7·5 μ in breadth; the spines are a little shorter than the cells (12–15 μ).

The variety *quadrispina* was very common in scum from Geduld Dam (No. 45); the type occurred in the plankton of Barberspan (No. 10) and Mtakati River (No. 32).

Distr. in Africa: North Africa, Algeria (F. Debray), Egypt (J. Brunnthaler, P. Kaufmann); Kordofan (G. Lagerheim); Abyssinia (G. B. De Toni); **French Equatorial Africa,** Ubangi (P. Frémy); Congo (E. de Wildemann); **Brit. East Af.** (O. Borge, W. and G. S. West), Nyasa, Tanganyika, Albert Nyanza (G. S. West), Victoria Nyanza (G. S. West, J. Woloszynska), Rukuga Lake and several places in the country surrounding Nyasa (W. Schmidle), Mohasi Lake (E. Lemmermann); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich), Transvaal (G. Huber-Pestalozzi), Little Namaqualand (G. S. West), Cape Colony (F. E. Fritsch and E. Stephens, G. S. West, G. Huber-Pestalozzi, P. Reinsch); Madagascar (W. and G. S. West), Azores (W. Archer, W. Farlow, W. Krieger), Madeira (R. Schodduyn).

In 1926 Chodat again contributed considerably to our knowledge of the morphology, genetic relations, and biology of the species of *Scenedesmus*. These studies were undertaken on material derived from pure cultures of a whole series of species. In this work, which, *inter alia*, gives valuable information on the range of variation, a large number of species have been described. Chodat has proved that these species are genetically, biologically, and morphologically distinct, and thus represent systematic units, which he has called species. From a systematic and morphological point of view, however, many of the species differ so little in form and size that the designation "variety" and "form" seem to me more appropriate than that of "species" (see, *e.g.*, figs. 19–22 in Chodat, 1926, pp. 126–132; figs. 134–135, pp. 230–231).

57. *Crucigenia minima* Brunnthaler, 1915, p. 174.

Among algae from Vereeniging waterworks (No. 41).
Distr. in Africa: not recorded in the literature.

58. *Crucigenia fenestrata* Schmidle; J. Brunnthaler, 1915, p. 174, fig. 252; H. Printz, 1915, p. 55, t. 4, fig. 104.

Among algae from Vereeniging waterworks (No. 41).
Distr. in Africa: S. Africa, Orange Free State (G. Huber-Pestalozzi).

59. *Coelastrum cambricum* Archer var. *intermedium* West, 1907, p. 136 (Syn.: *Coelastrum pulchrum* Schmidle var. *intermedium* Bohlin, 1897, p. 35, t. 2, figs. 16–17).

In the plankton of Florida Lake (No. 24), Brakpan (No. 5).
Distr. in Africa: Brit. East Af. (O. Borge), Nyasa (G. S. West), Country surrounding Nyasa, Malomba Lake (W. Schmidle), Victoria Nyanza (J. Woloszynska), Mohasi Lake (E. Lemmermann).

60. *Coelastrum reticulatum* Senn, 1899, p. 40, figs. 1–5, t. 2, figs. 1–10 (Syn.: *Hariotina reticulatum* Dangeard in Le Botaniste, 1889, p. 162; K. Bohlin, 1897, p. 37, t. 2, figs. 28–32).

In the plankton of Florida Lake (No. 24), Mtakati River (No. 32).
Distr. in Africa: Brit. East Af. (O. Borge), Victoria Nyanza (C. H. Ostenfeld, W. Schmidle, G. S. West, J. Virieux, J. Woloszynska), Nyasa (W. Schmidle, G. S. West), Albert Nyanza (G. S. West), Ikapo Lake (W. Schmidle); **S. Africa,** Transvaal (G. Huber-Pestalozzi), Griqualand West (F. E. Fritsch and F. Rich); Azores (K. Bohlin).

61. *Ankistrodesmus falcatus* Ralfs; G. S. West, 1904, p. 223, fig. 94 *A*; K. Berg and G. Nygaard, 1929, p. 309, t. 6, figs. 14–16.

In the plankton of Vaal River Dam (No. 26), among algae from Vereeniging waterworks (No. 41).
Distr. in Africa: North Africa, Algeria (F. Debray); Abyssinia (G. Lagerheim); **French Equatorial Africa,** Ubangi (P. Frémy); Congo (E. de Wildemann); **Brit. East Af.** (O. Borge, W. and G. S. West), Victoria Nyanza (W. Schmidle, G. S. West, J. Woloszynska), Nyasa and surrounding country (W. Schmidle, G. S. West), Tanganyika (G. S. West); **S. Africa,** Natal (F. E. Fritsch and F. Rich), Cape Colony (F. E. Fritsch, G. Huber-Pestalozzi); Madagascar (W. and G. S. West), Azores (W. Archer, K. Bohlin, W. Farlow, W. Krieger), Madeira (R. Schodduyn).

Var. *spirilliformis*, G. S. West, 1904, p. 224; K. Berg and G. Nygaard, 1929, p. 309, t. 6, fig. 17.
In the plankton of Brakpan (No. 3), among algae from Vereeniging waterworks (No. 41), Geduld Dam (No. 45).
Distr. in Africa: North Africa, Egypt (G. S. West); **Brit. East Af.,** Tanganyika (G. S. West); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich), Cape Colony (F. E. Fritsch, W. Hodgetts); Azores (W. Krieger).

ULOTRICHACEAE

62. *Ulothrix punctata* n. sp.—**(Fig. 28.)**

Filaments unbranched, several mm. long. Cell-walls, which often have H-shaped pieces inserted among them, very thin and provided with extremely delicate rows of punctations arranged in spirals. One lateral chromatophore with one distinct pyrenoid, generally of the same length as the cell, and extending more than half-way round the wall; in other cases the chromatophores are shaped like narrow, coarsely and irregularly dentate bands. Cells 0·9–3·6 times as long as broad, 4·5–5 μ broad and 4–18 μ long. Asexual reproduction obviously only takes place by means of zoospores (macrozoospores), one developed in each cell, the cells in question being 4–8 μ in length.

Attached to rocks in a waterfall at Alberton (No. 49).

Iodine dissolved in potassium-iodide stained the cell-contents intensely brown. Chlor-zinc-iodide stained the cell-walls a pure brown colour. Hydrochloric acid did not stain the chromatophores blue-green. The chemical reactions (apart from the hydrochloric acid test) seem to indicate that the species belongs to the Heterokontae, while the cell-contents suggest that it is a genuine member of the Chlorophyceae. I do not attach too great an importance

to the iodine test as a means of demonstrating starch, because genuine Chlorophyceae may lack starch under certain conditions. The fact that the present alga possesses a pyrenoid seems to be highly indicative of a faculty for developing starch. It seems to me more correct to lay most stress on the internal structure of the cell rather than on the presence of certain chemical products in the cell-wall.

There is hardly any doubt that the specimens ought to be referred to either *Ulothrix* or *Hormidium*. The asexual reproduction of the former generally takes place by means of zoospores, while asexual multiplication of *Hormidium* generally occurs by akinetes (H. Printz, 1927, pp. 163, 166). The number of cilia of the macrozoospores, as well as the breadth of the chromatophore and the habitat of the alga, are different in the two genera, *Ulothrix* having quadriciliate macrozoospores and a chromatophore which generally reaches more than half-way round the wall, and mostly occurring in running or stagnant water, while *Hormidium* has biciliate macrozoospores, a chromatophore which reaches at most half-way round the wall, and generally occurs in dripping water or as a subaërial alga (W. Heering, 1914, pp. 2–3).

Several of the filaments in the present material had developed macrozoospores, many of which had escaped before fixation, leaving an empty cell with an aperture in the wall; some few, however, had been fixed at the moment of

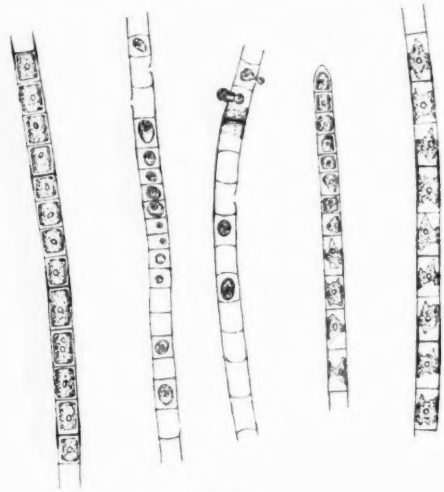


FIG. 28.

FIG. 29.

FIG. 28.— *Ulothrix punctata* n. sp. × 604. FIG. 29.— *Rhaphidonema brevirostre* Scherffel. × 755.

escape from the aperture (see fig. 28). No cilia were seen on the macrozoospores. Akinetes or aplanospores were not observed.

Considering the facts stated above, the form of the chromatophores, and the habitat of the alga (a waterfall), there is every probability that we are concerned with an *Ulothrix*, even if the cell-wall deviates somewhat from the type hitherto known among the species of this genus (see, however, H. Printz, 1927, p. 159).

The species is closely related to *U. subtilissima* Rab. (*cf.* W. Heering, 1914, p. 31, fig. 26), which is, however, stated to reproduce asexually by akinetes. None of the species described by Heering have the characteristic **H**-shaped pieces in the wall; this feature is easily observed without using immersion objectives. On the other hand, the rows of punctations on the wall, which are also not recorded in any species of Ulothrix, may easily have escaped the attention of earlier authors, since they are only visible through the very best immersion objectives.

63. *Rhaphidonema brevirostre* Scherffel, 1910, p. 116, figs. 1–5.—**(Fig. 29.)**

Filaments very short, with 3–5 cells, slightly curved and tapering at both extremities, although one end is more drawn out than the other; length of filaments 27–62 μ. Cells 3–5 μ broad, 1·5–4 times as long.

The discovery of this species is remarkable; to my knowledge, it has not been found again since 1910, when A. Scherffel described it from an alpine habitat in the Tatra Mountains.

Among algae from Port St. Johns (No. 50).

CHAETOPHORACEAE

64. *Draparnaldia Ravenelii* Wolle, 1887, p. 110, t. 95.—**(Figs. 30–31.)**

Thallus flaccid, up to 8 cm. in length and up to 0·7 mm. thick. Cells of the ***main filament*** cylindrical or barrel-shaped, 160–200 μ broad, 1–2 times as long; chromatophore (seen well preserved only in a few cells) in the form of

a narrow band (half as broad as the length of the cell) disposed laterally and showing deep and irregular longitudinal splitting. ***Branches*** solitary or opposite or three disposed verticillately so that the angles between the three branches are 90°, 90°, and 180° ; the branches of the second order may also have this curious position in relation to those of the first order. *Branchlets* rounded in outline, very small and numerous, 2–4 in number at each septum in the main filament and the branches ; thickness of cells of the branchlets 6–16 μ ; when two or four branchlets are present their position in relation to the main axis is opposite or decussate, when there are three it is obviously accidental.

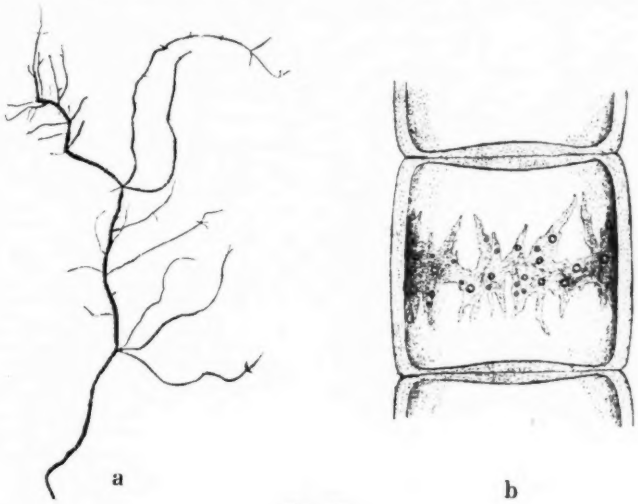


FIG. 30.

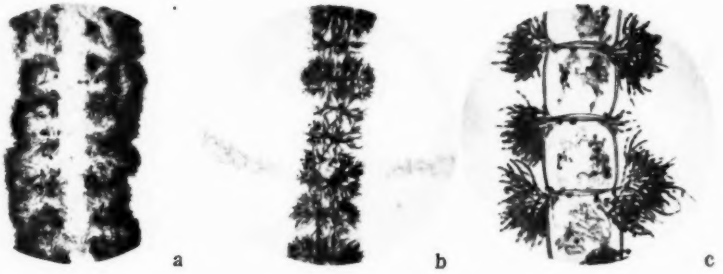


FIG. 31.

FIGS. 30–31.—*Draparnaldia Ravenelii* Wolle.

FIG. 30.—*a*, The thallus in natural size ; *b*, The main filament × 225. FIG. 31.—From photomicrographs ; *a*, The main filament ; *b*, A branch, both × 21·5 ; *c*, A branch, × 67.

The branchlets are sessile, three or four branches proceeding from the basal cell. *Hairs* of the usual type found in Draparnaldia present, but these are very short and extremely rare.

In Rietfontein (No. 38).

As far as I can see from Wolle's description and rough drawings, the present specimens must be identical with *D. Ravenelii* Wolle, which differs from the other species of *Draparnaldia* in several respects. In the first place, we have the large dimensions of the thallus (see fig. 30*a*, which shows a thallus natural size) and especially the characteristic verticillate branchlets. Their outline may vary, as the three or four branches proceeding from the basal cell are greatly branched. Not only on the main filament, but even on the young branches, the branchlets may be so copiously branched

and entangled that the impression is sometimes received that the whole surface of the main filament is covered by branchlets (fig. 31*a*). The 2–4 branchlets projecting from the upper part of each cell will, however, as a rule, be arranged in a more or less distinct verticillate manner round each septum (see fig. 31*b*), which gives the alga a considerable similarity to the genus *Batrachospermum*.

The cell-walls of the main filament were coloured violet-red with iodine, while the cell-contents were stained brown in the vast majority of cases. Under high magnifications it was recognised, however, that a few of the cells contained a ligulate, lateral chromatophore split longitudinally, and containing many pyrenoids, surrounded by a great number of black-blue grains of starch (see fig. 30*b*). The presence of the starch-grains, the appearance of the cells and hairs (see fig. 31*c* to the extreme right), and the absence of sexual organs and mucus, indicates that the present form is not a *Batrachospermum*.

Several of the cells of the branchlets were tumid and evidently very rich in nutriment. These cells were no doubt about to produce zoospores.

The discovery of this species is noteworthy. To my knowledge it has not been found again since 1887, when it was described by F. Wolle on the basis of material from North America.

COLEOCHAETACEAE

65. *Coleochaete orbicularis* Pringsheim, 1860, p. 11, t. 1, fig. 5.

Thallus circular, cells 8–15 μ broad, 1–2 times as long.

Among algae from Rietfontein (Nos. 38–39), especially on the coenocytes of *Hydrodictyon indicum* occurring in No. 39.

Distr. in Africa: S. Africa, Cape Colony (F. E. Fritsch and E. Stephens); the list for the distribution of this species is not complete.

OEDOGONIACEAE

66. *Oedogonium pseudospirale* n. sp.—**(Fig. 32.)**

Oogonia solitary, ellipsoid-spherical, with an oblong pore disposed a little above the middle, wall of oogonium always colourless; oogonia 1–1·3 times as long as broad, 40–44 μ broad and 44–56 μ long. Oospores 35–40 μ in diameter, not filling the oogonia, spherical, provided with irregularly dentate, spiral ridges, which sometimes anastomose; six or seven such ridges visible across the oospore; the two starting-points of the spiral ridges face the lateral wall of the oogonium; wall of oospore pale brown. Vegetative cells 5–6·2 times as long as broad, 14–17 μ broad, 86–90 μ long. Supporting-cells not or very slightly tumid, 18–20 μ broad. Neither male threads, nor dwarf-males, nor antheridia were encountered. The species is probably dioecious-macandrous.

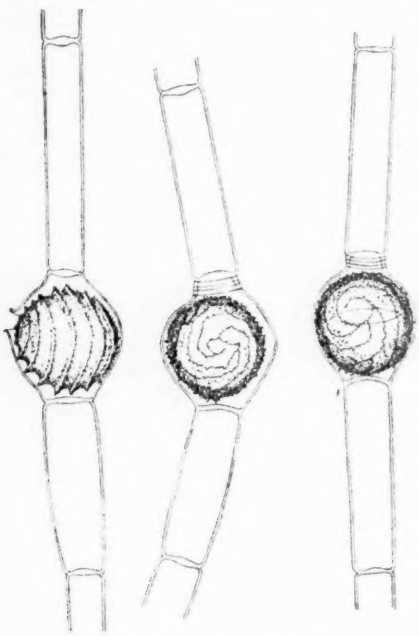


FIG. 32.—*Oedogonium pseudospirale* n. sp. ×378.

In floating scum from a pond near Alberton (No. 42).

This species is rather closely related to *O. spirale* Hirn (1900, p. 201, t. 33, fig. 206), var. *acutum* West (1902, p. 128, t. 17, figs. 3–5; see also H. Skuja, 1927, p. 102, t. 2, fig. 14*a–b*).

Differences in the size of the oogonia and vegetative cells, as well as the fact that *O. spirale* Hirn var. *acutum* West is nannandrous, having dwarf-males, which are not found in the present species, make me regard it as new. How much systematic importance should be attached to the latter character is a difficult question; Hirn obviously lays great stress on it, for he states (1900, pp. 41–42) that a whole series of species may be confused if the distribution of their sexual organs is unknown.

Young plants of the form figured in fig. 33 were found on this species, but they were extremely rare.

67. *Oedogonium porrectum* Nordst. et Hirn var. *africanum* n. var.—**(Fig. 33.)**

Oogonia solitary, very rarely in series of 2–4, and then always separated from one another by sterile cells, ellipsoid or obovate, opening by a circular split (operculum) in the superior part; wall of oogonium colourless, rarely yellowish-brown; oogonia 1·8–2·1 times as long as broad, 33–45 μ broad, 69–89 μ long. Oospores ellipsoid, far from filling the oogonia, membrane smooth, of two or three layers, yellowish-brown when mature, oospores 1·3–1·5 times as long as broad, 30–38·5 μ broad, 40–57 μ long. Vegetative cells 5·7–8 times as long as broad, 14–19 μ broad, 80–135 μ long. Supporting cells in a few cases with a thickened wall, otherwise not differing from vegetative cells. Antheridia, male threads or dwarf-males not observed. The variety is prob-

ably dioecious-macandrous. Young plants are very common on the filaments, but especially on the oogonia, being attached by means of rhizoids.

In floating scum from a pond near Alberton (No. 42).

In spite of a most thorough search I failed to find either dwarf-males or male threads. Since the characteristic short cells that produce spermatozoids were never seen on filaments with oogonia, the species is probably dioecious-macandrous. In addition to the young plants supposed to belong to this species (see fig. 33), specimens of *O. tapeinosporum* Wittr. var. *Angolense* West also occurred on the oogonia attached by the curious hemispherical basal cells.

The new variety differs from the type in its broader and relatively longer vegetative cells, in its considerably larger oogonia, and in its larger and more elongate oospores; for the vegetative cells (female thread) of the type are

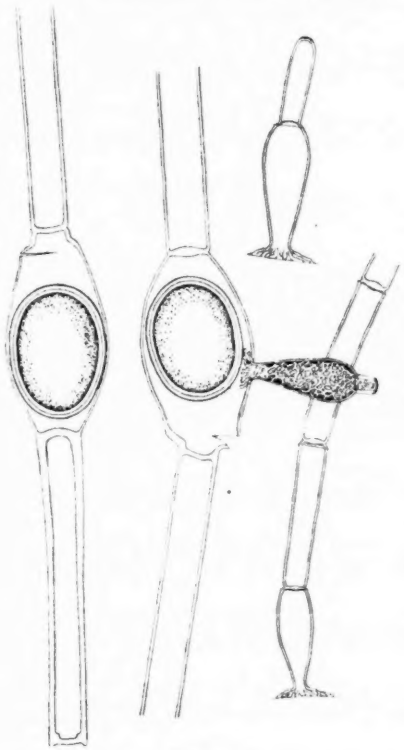


FIG. 33.

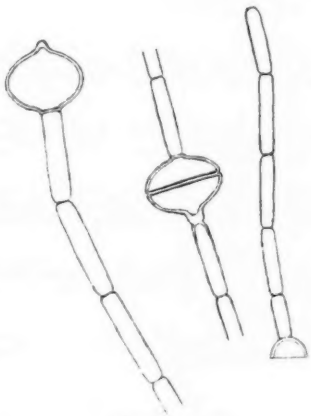


FIG. 34.

FIG. 33.—*Oedogonium porrectum* Nordst. et Hirn, var. *africanum* n. var. × 378.
FIG. 34.—*O. tapeinosporum* Wittr. var. *Angolense* West. × 755.

only 7–10 μ broad and 3·5–5·5 times as long, the oogonia are 24–27 μ broad and 44–53 μ long, the oospores 23–24 μ broad and 25–28 μ long (K. Hirn, 1900, p. 186, t. 29, fig. 183).

68. *Oedogonium tapeinosporum* Wittr. var. *Angolense* West, 1897, p. 5.—**(Fig. 34.)**

Oogonia solitary, depressed-globose, circular when viewed from above, colourless, opening by a relatively broad circular split (operculum) at the middle of the oogonium; oogonia 0·9–1·0 times as long as broad, 13–14 μ long, 14–15·5 μ broad. Oospores colourless, filling the oogonia completely. The specimens probably dioecious-macandrous. Vegetative cells 3–6·7 times as long as broad, 2·5–3·5 μ broad, 10–20 μ long. Supporting cells not differing from the vegetative ones. Basal cell more or less hemispherical, 7·5–8 μ broad.

The measurements for the vegetative cells are slightly smaller than those given by W. and G. S. West (3·8–4·5 μ); the oogonia are also not quite as broad, Messrs. West's specimens measuring 18–19 μ. The reason for referring the present specimens to var. *Angolense* West and not to the type is that, while *O. tapeinosporum* Wittr. has oogonia

which are as long or longer than broad (see Hirn, 1900, p. 297, t. 23, fig. 117), those of both var. *Angolense* and of the present specimens are shorter than broad, or at most as long.

In floating scum from a pond near Alberton, on *Oedogonium porrectum* var. *africanum* (No. 42).

Distr. in Africa: Angola (W. and G. S. West).

DESMIDIACEAE

69. *Closterium acutum* Bréb. ?; W. and G. S. West: Monograph I, 1904, p. 177, t. 23, figs. 9–14.

The specimen seen was 153 μ long and 3 μ broad; it had four pyrenoids per semicell and one moving granule in the terminal vacuoles, which were not very long, somewhat as in fig. 12 (*loc. cit.*); cell almost straight, its form corresponding very well to fig. 11 (*loc. cit.*).

Since only one individual was observed, it is impossible to decide with certainty whether it really belongs to *C. acutum* Bréb. According to E. Wehrle (1927, p. 271), this species was in Northern Europe found exclusively in acid water (pH, 4·1–6·2). Since it has, however, been found in Tanganyika (*cf.* the list below), which undoubtedly has water with an alkaline reaction, this fact does not exclude its also occurring in Florida Lake.

In the plankton of Florida Lake (No. 23).

Distr. in Africa: North Africa, Algeria (F. Debray), Egypt (P. Kaufmann); **Brit. East Af.** (W. Schmidle), Nyasa, Tanganyika (G. S. West); **S. Africa,** Cape Colony (W. Hodgetts).

70. *Closterium polystictum* n. sp.—**(Fig. 35.)**

Cells large, much elongated and narrow, 48–60 times longer than their diameter, slightly and often irregularly curved, median portion of the cell fairly straight and cylindrical, gradually attenuated towards the extremities, near the apices rather suddenly narrowed into a subacute cone; cell-wall smooth and colourless; chromatophores with a median series of 12–16 pyrenoids in each semicell; terminal vacuoles relatively short (25–43 μ). Length 479–585 μ, breadth 9–11 μ, breadth near apices 6·5–7 μ.

In the plankton of Vaal River Dam, Vereeniging (Nos. 25–26).

Characteristic of this species are the abruptly attenuated apices and the elongate chromatophores with the great number of pyrenoids. The long and narrow species of *Closterium*, which sometimes occur in freshwater plankton, generally have cells tapering gradually from the middle towards the apices. The table below, which gives the measurements for two cells, shows that the cell decreases very slightly in thickness from the middle (11 μ) to the ends of the chromatophore (7 μ); within the short distance from here to the apex of the cell the abrupt tapering of the cell takes place.

Thickness of cell at the middle.	Thickness of cell at the end of chromatophore.	Length of vacuoles.	Length of cell.	Number of pyrenoids per semicell.
11 μ	7 μ and 7 μ	25 μ and 29 μ	529 μ	14
11 μ	7 μ and 7 μ	27 μ and 43 μ	551 μ	15

71. *Closterium moniliferum* Ehrb. ?; W. and G. S. West: Monograph I, 1904, p. 142, t. 16, figs. 15–16.—**(Fig. 36.)**

Cells of medium size, 4·4–5·3 times longer than their diameter, outer margin 118–129° of an arc, inner margin inflated in the median part; cells gradually attenuated towards the rounded apices; cell-wall smooth and colourless; chromatophores with about ten ridges and a more or less central series of 4–9 pyrenoids. Length 246–272 μ, breadth 51·5–56 μ, breadth of apices 7–10 μ.

The specimens are rather closely allied to *C. moniliferum* Ehrb. and *C. Ehrenbergii* Menegh. The latter, however, differs from the present specimens in the numerous pyrenoids scattered in the chromatophores and in the very large cells. The two specimens observed differ from *C. moniliferum* Ehrb. in their greater curvature, their relatively shorter cells, and the greater number of ridges on the chromatophores; further, the number of pyrenoids (4–9) does not agree with that of *C. moniliferum* Ehrb. (6–7), and the pyrenoids are not disposed in a median series as in that species. O. Borge has described and figured a series of forms of this species from British East Africa (1928, p. 99, t. 1, figs. 7–8), which shows that *C. moniliferum* Ehrb. may be very variable, especially in the degree of curvature and the number of pyrenoids per semicell.

Unfortunately I have only found the two specimens figured, which show some points of difference, so that a certain identification is impossible.

Among algae from Rietfontein (No. 39).

Distr. in Africa: North Africa, Algeria (F. Debray), Egypt (J. Brunnthaler); **Brit. East Af.** (O. Borge), Nyasa (W. Schmidle); **S. Africa,** Natal (F. E. Fritsch and F. Rich), Little Namaqualand (G. S. West), Cape Colony (F. E. Fritsch and E. Stephens, W. Hodgetts).

72. *Closterium lineatum* Ehrb.; W. and G. S. West: Monograph I, 1904, p. 181, t. 24, figs. 1–5.

Cells 23–30 times longer than their diameter; 19–20 striae visible across the cell. Length 480–564 μ, breadth 19–21 μ, breadth of apices 6–7 μ.

The specimens differ from *C. lineatum* Ehrb. as described by W. and G. S. West only in the cells being 23–30 times as long as broad ; W. and G. S. West give 16–24 times.

Among algae from Rietfontein (No. 39).

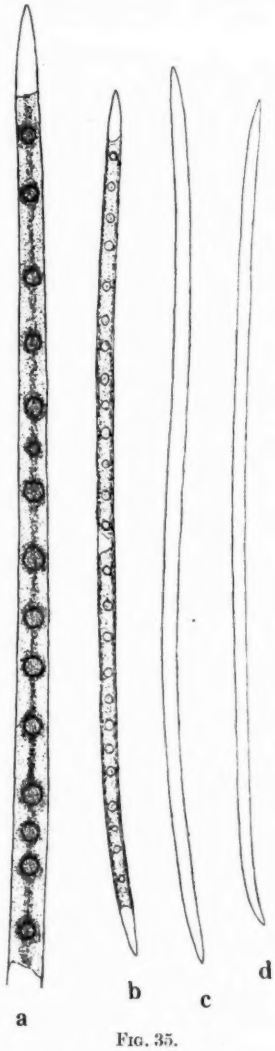


FIG. 35.

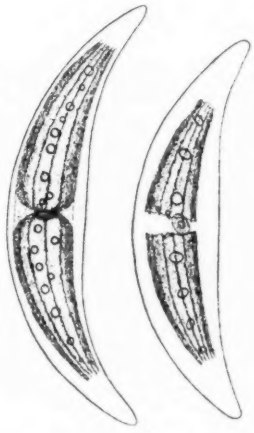


FIG. 36.

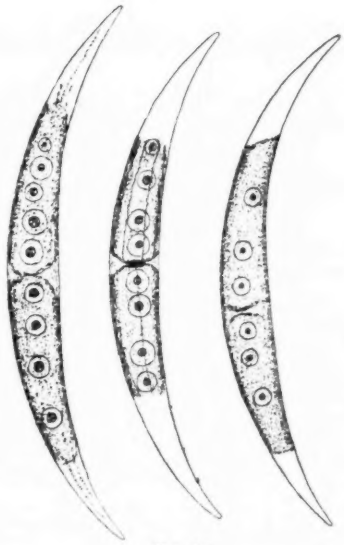


FIG. 37.

FIG. 35.—*Closterium polystictum* n. sp.: *a*, a semicell (×465), *b–d*, 3 specimens (×235).
FIG. 36.—*C. moniliferum* Ehrb.? ×233.
FIG. 37.—*C. peracerosum* Gay var. *arcuatus* Fritsch et Rich. ×372.

Distr. in Africa: North Africa, Egypt (J. Brunnthaler); **Brit. East Af.** (variety, W. Schmidle); **S. Africa,** Natal (F. E. Fritsch and F. Rich), Cape Colony (form, G. Huber-Pestalozzi).

73. *Closterium peracerosum* Gay var. *arcuatus* Fritsch et Rich, 1929, p. 56, fig. 16 *A–B*.—**(Fig. 37.)**

Cells of medium size, usually 9·1–12·5 times longer than their diameter, strongly curved, outer margin about 92–104° of an arc, inner margin not or very slightly tumid, gradually attenuated towards the apices, which are acutely rounded and without thickenings; cell-wall smooth, colourless; chromatophores obscurely ridged, with a single series of 3–5 pyrenoids in each semicell; terminal vacuoles 37–54 μ long. Distance between apices 197–245 μ, breadth 19–26 μ, breadth of apices 2–2·5 μ.

The table below gives the measurements for seven individuals; the second column gives the length of cell, the third the breadth, the fourth the relation between length and breadth, the fifth the curvature, and the sixth the number of pyrenoids per semicell.

No. 1.	199 μ.	19 μ.	10·5×.	101°.	3 pyrenoids.
No. 2.	197 μ.	20 μ.	9·8×.	96°.	4 ,,
No. 3.	217 μ.	20 μ.	10·8×.	92°.	4–5 ,,
No. 4.	238 μ.	26 μ.	9·1×.	104°.	4 ,,
No. 5.	245 μ.	20 μ.	12·5×.	95°.	3 ,,
No. 6.	202 μ.	19 μ.	10·6×.	—	3 ,,
No. 7.	217 μ.	22·5 μ.	9·6×.	—	3 ,,

Several specimens of this variety were observed in the plankton from Brakpan, taken on September 7, 1927. In the autumnal samples, from February, March and April 1928, it was not found. It should thus be a vernal form. It is characteristic of its ecology that it occurs in the natural pans.

In the plankton of Brakpan (No. 1).

Distr. in Africa: S. Africa, Griqualand West (F. E. Fritsch and F. Rich).

74. *Euastrum evolutum* West var. *integrius* West, 1895, p. 244, t. 14, figs. 23–25.—**(Fig. 38.)**

The specimen observed deviates only immaterially from those of W. and G. S. West. The number of inferior lateral spines, which in the original specimens was four, was here only three (fig. 38). Length 46 μ, breadth 31 μ, breadth of isthmus 7 μ.

Among algae from Zambesi River (No. 51).

The type is recorded from **Brit. East Af.** (W. Schmidle).

75. *Cosmarium margaritatum* Roy et Biss.; W. and G. S. West: Monograph IV, 1911, p. 18, t. 99, fig. 10.—**(Fig. 39.)**

The individual recorded corresponds very well to the diagnosis in Messrs. West's monograph, except that 16–17 oblique decussating series of granules are visible across the semicell; Messrs. West give about 12. Further, the semicells were nearly as strongly rounded as in f. *subrotundata* West (*loc. cit.*, t. 100, fig. 1), which, however, has hollow granules, and this is not so in the present specimen. Length 102 μ, breadth 80 μ, breadth of isthmus 32 μ; 35–36 granules visible at the margin of the semicell; two pyrenoids in each semicell.

Among algae from Rietfontein (No. 39).

Distr. in Africa: Brit. East Af., Nyasa, Tanganyika (G. S. West); Angola (Form, W. and G. S. West).

76. *Cosmarium scopulorum* Borge, 1923, p. 12, t. 1, fig. 14.—**(Figs. 40-41.)**

Cells small, as a rule a little longer than broad, deeply constricted, sinus narrowly linear, without any dilatation at the apex; semicells broadly hexagonal, angles rounded, upper lateral margins very slightly concave, apex broadly truncate, straight or rounded; side view of semicell subcircular, with a prominent tumour on each side; vertical view elliptic, with a prominent tumour at the middle on each side; ratio of axes (without papilla) 1 : 1·8–2·0; cell-wall smooth; chromatophore axile with a central pyrenoid. Length 16–22 μ, breadth 15–17 μ, thickness 9–10 μ, breadth of isthmus 4·5–5·5 μ.

In the plankton of Brakpan (No. 1), Barberspan (Nos. 9–10).

Fig. 40 shows individuals from Brakpan, where the species was the dominant form of the plankton on September 7, 1927. Fig. 41 represents an individual from Barberspan; the specimens were shorter than those from Brakpan, but otherwise the same. Fig. 40 shows different forms of cells, *c* and *d* being the characteristic ones, while *a* and *b* are rare. The specimens agree excellently with Borge's description and figure of *C. scopulorum*, except that the tumour on the semicells is a little more prominent. *C. scopulorum* Borge is very closely allied to the variable species *C. polygonum* Archer (see W. and G. S. West: Monograph III, 1908, p. 76, t. 71, figs. 32–34). Compare also *C. polygonum* Archer var. *minus* Hieronymus (W. Schmidle, 1898, p. 32, t. 2, fig. 6).

As mentioned above, the species was very common in September in Brakpan, but it was not observed in the samples of February, March, and April 1928. As, however, several specimens were seen in the April samples from Barberspan, it is difficult to pronounce on its periodicity. It is ecologically interesting because it attains so vigorous a development in the natural pans with their occasional high content of mineral salts. Borge found it originally on irrigated rocks under quite different ecological conditions.

Distr. in Africa: S. Africa, Cape Colony (W. Hodgetts).

77. *Cosmarium subtumidum* Nordst. var. *Klebsii* W. and G. S. West, Monograph II, 1905, p. 193, t. 63, figs. 21–23.—**(Fig. 42.)**

Length of cells 30 μ, breadth 24 μ, thickness 14 μ, breadth of isthmus 7 μ, and breadth of apices 9 μ. W. and G. S. West (*loc. cit.*) do not give the measurements for the apices. To judge from their figures, the apices of *C. subtumidum* Nordst. are about half as broad as the cell; in var. *Klebsii* West they are distinctly smaller than half the breadth of the cell, so that it is evident that the present individuals should be referred to var. *Klebsii* West.

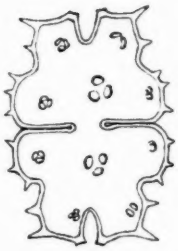


FIG. 38.

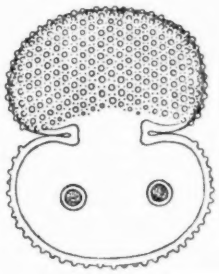


FIG. 39.

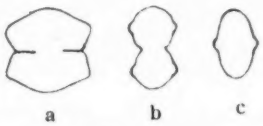


FIG. 41.

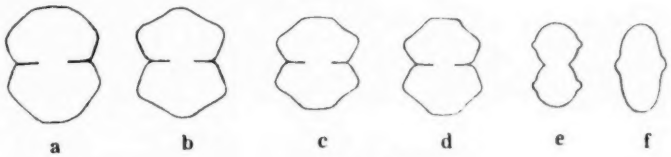


FIG. 40.

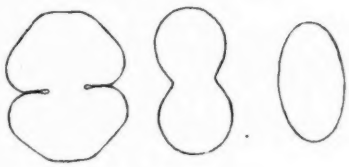


FIG. 42.

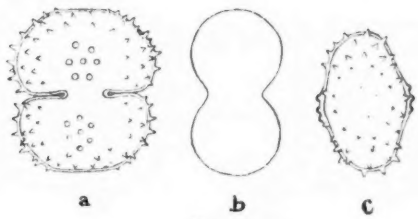


FIG. 43.

FIG. 44.

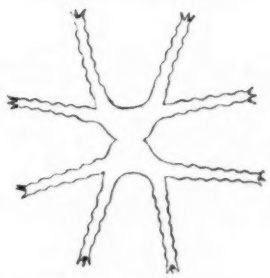


FIG. 45.

FIG. 38.—*Euastrum evolutum* West var. *integrius* West. ×755.

FIG. 39.—*Cosmarium margaritatum* Roy et Biss; in the lower semicell the structure of the cell-wall is not drawn, but the two pyrenoids are shown. ×378.

FIG. 40.—*C. scopulorum* Borge, individuals from Brakpan; *a–d*, front view, *e*, side view, *f*, vertical view; *a* and *b* ×800, *c–f* ×755.

FIG. 41.—*C. scopulorum* Borge, individual from Barberspan; *a*, front view, *b*, side view, *c*, vertical view; all ×800.

FIG. 42.—*Cosmarium subtumidum* Nordst. var. *Klebsii* West. ×755. FIG. 43.—*C. trachypleurum* Lund. var. *spinosum* West; *a*, front view; *b*, side view (the spines are not drawn); *c*, vertical view; all ×566. FIG. 44.—*Staurastrum dejectum* Bréb. var. *patens* Nordst. forma. ×800. FIG. 45.—*S. bibrachiatum* Reinsch var. *cymatium* West. ×800.

In the plankton of Mtakati River (No. 32), among algae from Zambesi River (No. 51).

Distr. in Africa: not recorded in the literature.

78. *Cosmarium trachypleurum* Lund. var. *spinosum* W. and G. S. West, 1895, p. 66, t. 7, fig. 17.—**(Fig. 43.)**

The present specimens properly take up an intermediate position between *C. trachypleurum* Lund. (see W. and G. S. West: Monograph III, p. 172, t. 81, figs. 2–3) and its var. *spinosum* W. and G. S. West, since the form of the semicells in front view corresponds closely to the latter, while the form in vertical view agrees better with the type, the semicells of which sometimes show a median tumour. As the median tumour according to W. and G. S. West is a variable character, I have, however, considered it more correct to identify the individuals with var. *spinosum* W. and G. S. West.

Among algae from Zambesi River (No. 51).

Distr. in Africa: Madagascar (W. and G. S. West); Natal (another variety, F. E. Fritsch and F. Rich).

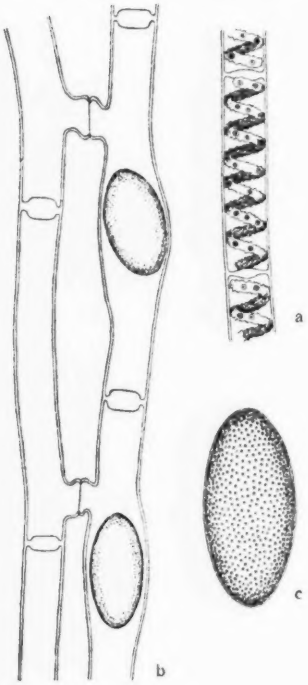


FIG. 46.

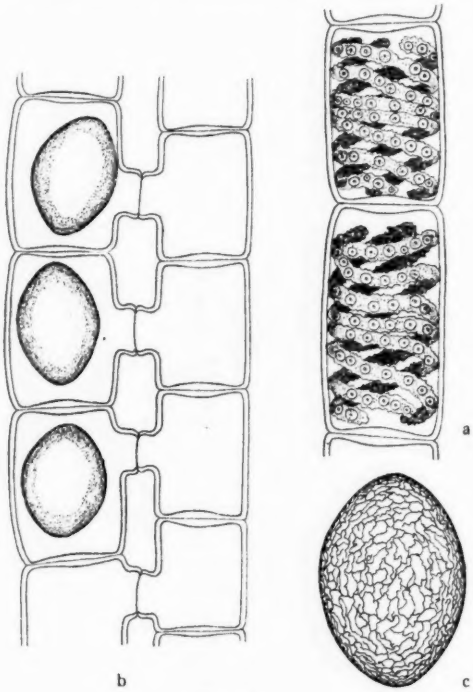


FIG. 47.

FIG. 46.—*Spirogyra Hoehnei* Borge var. *robusta* n. var.; *a*, Vegetative cells (×233); *b*, Conjugating cells (×233); *c*, a zygospore (×378).

FIG. 47.—*Spirogyra Reinhardi* Chmiel var. *africana* Fritsch et Rich; *a*, Vegetative cells (×233); *b*, Conjugating cells (×233); *c*, a zygospore (×378).

79. *Staurastrum dejectum* Bréb. var. *patens* Nordst. forma; O. Norstedt, 1881, p. 39, t. 4, fig. 16.—**(Fig. 44.)**

The specimen observed agrees very well with Nordstedt's figure, except that the spines are longer, viz. 5–6 μ, and that the sinus is rounded at the apex. Length 26 μ, breadth 24 μ, breadth of isthmus 7 μ.

In the plankton of Florida Lake (No. 24).

The type is recorded from the Congo (E. de Wildemann) and from British East Africa (G. Hieronymus), where also the variety in question is found (W. Schmidle).

80. *Staurastrum paradoxum* Meyen; W. and G. S. West and N. Carter: Monograph V, 1923, p. 101, t. 145, figs. 1–5.

In the plankton of Florida Lake (Nos. 23–24).

Distr. in Africa: Brit. East Af., Victoria Nyanza (J. Woloszynska); **S. Africa,** Griqualand West (F. E. Fritsch and F. Rich).

81. *Staurastrum bibrachiatum* Reinsch var. *cymatium* W. et G. S. West, 1895, p. 74, t. 8, fig. 28.—**(Fig. 45.)**

Length without processes 12·5 μ, with processes 49 μ, breadth with processes 47·5 μ, breadth of isthmus 5·5 μ. The appearance of this variety is very characteristic and, to judge from the records, it is extremely rare.

In the plankton from Barberspan (Nos. 9–10).

Distr. in Africa: Madagascar (W. and G. S. West); Azores (K. Bohlin).

ZYGNEMATACEAE

82. *Zygnema pectinatum* Ag.; O. Borge, 1913, p. 33, fig. 49.

The measurements of my specimens are as follows: Vegetative cells 32–37 μ broad, 47–64 μ long, breadth of zygospores 40–49 μ, length 50–70 μ. The zygospores were obviously not quite mature. The thickness of the zygospore is recorded as 35–40 μ.

In Rietfontein (No. 38).

Distr. in Africa: North Africa, Cyrenaica (G. B. De Toni and A. Forti); **S. Africa,** Natal (F. E. Fritsch and F. Rich), Cape Colony (F. E. Fritsch and E. Stephens).

83. *Spirogyra Hoehnei* Borge var. *robusta* n. var.—**(Fig. 46.)**

Vegetative cells 29–35 μ, 1·8–6 times as long as broad, with simple septa; one chromatophore, making 2·5–8 turns. Cells containing zygospores elongated, 7·5–8·5 times as long as broad, tumid in the median portion, 43–65 μ thick in the middle, 233–249 μ long. Zygospores elliptical, 32–60 μ broad, 54–104 μ long, 1·7–2·2 times as long as broad (19 measurements). Exosporium smooth, colourless, mesosporium yellowish-brown, with faint, irregular scrobiculations (?).

In "heleoplankton" from Rietfontein (No. 12).

Among the species of Spirogyra, *S. Hoehnei* Borge (1925, p. 13, t. 2, fig. 1) is most like the present specimens. This species is, as a matter of fact, closely allied to *S. punctata* Cleve (Borge, 1913, p. 21, fig. 16; P. Petit, 1880, p. 24, t. 9, figs. 9–11). *S. Hoehnei* Borge differs from the new variety in having vegetative cells 6–12 times as long as broad, and smaller zygospores, 32–37 μ broad and 50–65 μ long.

I was unable to determine whether the mesosporium is faintly scrobiculate or faintly verrucose, in spite of examination with an immersion objective (n. Ap. 1·30). The zygospores were measured in three pairs of conjugating threads, and the following results obtained: The first pair had zygospores 1·7–1·9 times as long as broad, 51–60 μ broad, 90–104 μ long; the zygospores of the second pair were 1·7–2·2 times as long as broad, 36–40 μ in breadth, 65–80 μ in length; those of the third pair were 1·7–1·8 times as long as broad, measuring 32–35 μ in breadth and 54–59 μ in length. These great variations in the size of the zygospores will naturally suggest the possibility that the new variety includes several forms. In sample 12 from Rietfontein abundant material of *S. scripta* n. sp. was present, while *S. Hoehnei* Borge var. *robusta* was fairly scarce. The vegetative thread shown in fig. 48 undoubtedly belongs to the conjugating threads depicted in the same figure, since a thread was observed having normal vegetative cells at one end and cells containing zygospores at the other. The scanty material of *S. Hoehnei* Borge var. *robusta* did not admit of finding a thread which, like that just mentioned, was vegetative at one end and fertile at the other, but occasionally a number of more or less degenerate cells, very distinctly containing a single chromatophore making about four turns, were intercalated between the cells containing zygospores. These facts make it probable that *a*, *b*, and *c* in fig. 46 belong to the same species.

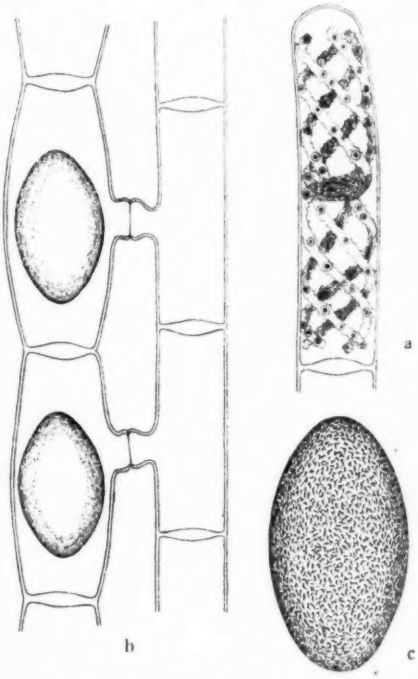


FIG. 48.—*Spirogyra scripta* n. sp.; *a*, Vegetative cell (×233); *b*, Conjugating cells (×233); *c*, a zygospore (×378).

84. *Spirogyra Reinhardi* Chmiel. var. *africana* Fritsch et Rich.—**(Fig. 47.)**

Vegetative cells 62–84 μ broad, 1·7–3·7 times as long, with simple septa; three or four chromatophores making 2–3 turns. Fructifying cells not or only slightly tumid, strongly abbreviated. Zygospores elliptical, often a little pointed, 1·3–1·4 times as long as broad (eight measurements), 54–65 μ broad, 70–84 μ long, with smooth exosporium; mesosporium brown with irregular reticulate thickenings.

The specimens are undoubtedly identical with *S. Reinhardi* var. *africana*, recorded from Griqualand West by Fritsch and Rich, from whose figures it appears that the zygospores were 1·3–1·5 times as long as broad. The cells of my specimens containing zygospores were in many cases not tumid, in others slightly tumid.

In the plankton of Mtakati River (No. 33; this alga has, of course, got into the plankton by mere chance).

Distr. in Africa: S. Africa, Griqualand West (F. E. Fritsch and F. Rich).

85. *Spirogyra scripta* n. sp.—**(Fig. 48.)**

Vegetative cells 51–64 μ broad, 4·4–5·6 times as long, with simple septa; 4–5 chromatophores making about two turns. Fructifying cells abbreviated, tumid, 67–71 μ thick. Zygospores elliptical, not flattened, often a little pointed, 1·6–1·8 times as long as broad (12 measurements), 54–60 μ broad, 91–107 μ long. Exosporium colourless and smooth, mesosporium brown, with a great number of close-set, more or less branched scrobiculations shaped like short streaks.

In "heleoplankton" from Rietfontein (No. 12).

To my knowledge no species of Spirogyra is recorded with a zygospore-membrane showing the peculiar structure of the present species. Viewed through an immersion objective the membrane looked as if covered with a great number of delicate, irregular, dark cracks, which were very distinctly marked against the brown wall.

HETEROKONTAE.

BOTRYOCOCCACEAE

86. *Botryococcus Braunii* Kg.; H. Printz, 1927, p. 386, fig. 289.

In the plankton of Barberspan (Nos. 9–10), Lake Chrissie (Nos. 18 and 20), Rietkuil (No. 21), Florida Lake (No. 24).

Distr. in Africa: Abyssinia (G. Lagerheim); **Brit. East Af.** (O. Borge, G. Hieronymus), Victoria Nyanza (C. H. Ostenfeld, W. Schmidle, G. S. West, J. Virieux, J. Woloszynska), Tanganyika, Nyasa (G. S. West), country surrounding Nyasa, Ikapo Lake, Itende Lake (W. Schmidle); **S. Africa,** Rhodesia, Transvaal, Orange Free State, Cape Colony (G. Huber-Pestalozzi); Azores (W. Archer, K. Bohlin, W. Farlow, W. Krieger).

CHARALES.

CHARACEAE

The determinations within this group of algae were undertaken by my friend Johannes Iversen, M.Sc., to whom I return my best thanks.

87. *Chara coronata* **Ziz.**

The specimens were delicate, encrusted in bands. Leaves short, consisting of only four joints.
In pan at Brakpan (No. 46).
Distribution: Europe, Asia, North America, Australia, and Africa.

88. *Chara fragilis* Desvaux.

In pan at Brakpan (No. 47).
Distribution: cosmopolitan.

89. *Nitella sp.*

Indeterminable sterile fragments.
Pan at Rietfontein (No. 48).

COPENHAGEN, *October* 1930.

LIST OF LITERATURE.

ARCHER, W. (1874): "Algae and Rhizopoda from the Hot Springs of Azores," Quart. Journ. Micr. Soc., **14**, p. 107.

ARCHER, W. (1875): "Notes on some Collections made from Furnas Lake, Azores, containing Algæ and a few other Organisms," Journ. Linn. Soc. Bot., **14**, pp. 328–340.

BELLOC, E. (1893): "Recherches sur les Algues des eaux douces, des eaux thermales, et des eaux salées d'Algérie, de Tunise, et du Maroc, etc," Rev. biol. Nord. Fr., 5e année. (Not seen.)

BELLOC, E. (1896): "Aperçu de la Flore algologique d'Algérie, de Tunise, du Maroc, et de quelques lacs de Syrie," Ass. fr. Av. Sc., Congrès de Carthage, pp. 406–412. (Not seen.)

BERG, K., and NYGAARD, G. (1929): "Studies on the Plankton in the Lake of Frederiksborg Castle," Mém. de l'Acad. Royale Scienc. Lettr. de Danemark, Copenhague, 9me série, t. I, pp. 227–316, t. 1–6.

BOHLIN, K. (1897): "Die Algen der ersten Regnell'schen Expedition, Protococcaceen," Bihang Kgl. Svenska Vet.-Akad. Handl., **23.**

BOHLIN, K. (1901): "Étude sur la Flore algologique d'eau douce des Azores," Bihang Kgl. Svenska Vet.-Akad. Handl., **27,** Afd. III, 85 pp., 1 t.

BORGE, O. (1911): "Süsswasseralgen aus Madeira," Botaniska Notiser, 1911, p. 206.

BORGE, O. (1921): "Die Algenflora des Takernsees," Sjön Takerns Fauna och Flora utgiven af K. Svenska Vetenskapsakademien, Stockholm, Nr. 4, 48 pp., t. 1–2, 3 text-figs.

BORGE, O. (1923): "Beiträge zur Algenflora von Schweden, III," Arkiv för Botanik, **18,** pp. 1–34, t. 1–2.

Borge, O. (1928): "Süsswasseralgen," in B. Schröder's Zellpflanzen Ostafrikas, gesammelt auf der Akademischen Studienfart 1910, Teil 8, Hedwigia, **68,** pp. 93–114, t. 1–2.

Borzi, A. (1914): "Alghe terrestri xerophile della Tripolitania," Boll. di studi ed inform. del R. Giard. bot. di Palermo, pp. 91–130. (Not seen.)

Braun, Alex. (1855): Algarum unicellularium genera nova vel minus cognita, præmissis observationibus de algis unicellularibus in genere. Lipsiae, 111 pp., 6 t.

Braun, Alex. (1867): Die Characeen Africas.

Brunnthaler, J. (1914): "Beitrag zur Süswasseralgenflora von Aegypten," Hedwigia, **54,** pp. 219–225, 2 text-figs.

Brunnthaler, J. (1915): "Protococcales," in A. Pascher's Süsswasserflora Deutschlands, Österreichs und der Schweiz, Heft 5, pp. 52–205, 330 text-figs.

Chodat, R. (1897): "Études de biologie lacustre," Bull. de l'Herb. Boissier, 5 année, pp. 289–314, t. 9–11.

Chodat, R. (1926): "Scenedesmus, Étude de génétique, de systématique experimentale et d'hydrobiologie," Revue d'Hydrologie, **3,** pp. 71–258, 162 text-figs.

Cohn, F. (1879): "Desmidiaceae Bongoenses," Festschr. Naturf. Gesell. Halle, pp. 3–14, t. 11.

Cooke, M. C. (1882–1884): British Freshwater Algæ. I, Text, 329 pp.; II, Plates, 130 t.

Crow, W. B. (1923): "The Taxonomy and Variation of the Genus Microcystis in Ceylon," The New Phytologist, **22,** No. 2, pp. 59–68, t. 1.

Debray, F. (1893): "Liste des Algues marines et d'eau douce récoltées jusqu'a ce jour en Algérie," Bull. scient. France et Belgique, **25,** pp. 174–192.

Debray, F. (1897): Catalogue des Algues du Maroc, d'Algérie et de Tunise, 78 pp. (Not seen.)

De Toni, G. B. (1891): "Ueber eine neue Tetrapedia-Art aus Afrika," Hedwigia, **4.**

De Toni, G. B. (1891): "Algae Abyssinicae a cl. Prof. O. Penzig collectae," Malpighia, **5,** pp. 261–273.

De Toni, G. B. (1895): "Terzo pugillo di Alghe Tripolitane," Rendiconti Cl. Sc. fis., math. nat. della R. Ac. Lincei, **4,** pp. 451–457.

De Toni, G. B., and Forti, A.: (1913) "Contribution à la flore algologique de la Tripolitaine et de la Cyrénaique," Ann. Inst. Océanogr., **5,** fasc. 7, pp. 1–56, 1 text-fig.

De Toni, G. B., and Forti, A. (1916): "Catalogo delle Alghe raccolte nella regione di Bengasi dal R. P. D. Vito Zanon," Atti Real. Inst. Veneto, **76,** Parte seconda, pp. 93–114.

De Toni, G. B., and Forti, A. (1916): "Algæ in R. Pampanini: Piante de Bengasi e del suo territorio raccolte dal Rev. P. D. Vito Zanon," Nuove Giorn. bot. ital., **23,** pp. 289–291.

Dickie, G. (1875): "On the Algae of Mauritius," Journ. Linn. Soc. Bot., **14,** pp. 190–202.

Dickie, G. (1879): "Notes on Algae from Lake Nyasa, East Africa," Journ. Linn. Soc., **17,** pp. 281–283, 1 text-fig.

Esmarch, F. (1910): "Beitrag zur Cyanophyceenflora unserer Kolonien," Jahrb. Hamb. Wiss. Anst., **28,** 3 Beih. (Not to be found.)

Farlow, W. G. (1897): "Myxophyceae," in W. Trelease's Botanical Observations on the Azores, 8th Annual Rep. Missouri Bot. Garden, pp. 188–199.

Forti, A. (1916): "Mixophycee della Somalia italiana," in E. Chiovenda's Le collezioni botaniche della missione Stefanini-Paoli, Firenze, p. 188.

Forti, A. (1927): "Su l'aspetto della Flora algologica nell' Oasi di Giarabub," N. Giorn. bot. ital., **34,** pp. 507–570.

Forti, A. (1929): "Elenco delle Alghe raccolte nel 1926 dal Prof. G. Krüger a Giarabub," *ibid.*, **35,** pp. 416–418, 2 text-figs.

Frémy, P. (1922): "Algues de l'Afrique équatoriale," Bull. Soc. Linn. Norm., 7e série, **5,** pp. 25–26. (Not seen.)

Frémy, P. (1922): "Algues croissant sur des Muscinées de Madagascar," *ibid.*, pp. 38–39. (Not seen.)

Frémy, P. (1923): "Cyanophycées du Haut-Oubanghi," *ibid.*, **6,** p. 8. (Not seen.)

Frémy, P. (1924): "Contribution à la flore algologique de l'Afrique équatoriale française," Rev. algol., **1,** pp. 28–49, 244–257, t. 3, 8 text-figs.

Frémy, P. (1925): "Quelques algues subaériennes de Madagascar," Bull. Soc. Linn. Norm., 7e série, **8,** pp. 27–28. (Not seen.)

Frémy, P. (1925): "Quelques algues des environs de Sousse (Tunisie)," Bull. Soc. Linn. Norm., 7e série, **8,** pp. 28–30. (Not seen.)

Frémy, P. (1930): "Les Myxophycées de l'Afrique équatoriale française," Archives de Botanique, III, pp. 1–508, 362 text-figs.

Fritsch, F. E. (1914): "Contributions to our Knowledge of the Freshwater Algae of Africa. 1. Some Freshwater Algae from Madagascar," Annales Biolog. lacustre, 1914, **7,** pp. 40–59, t. 1.

Fritsch, F. E. (1918): "Contributions to our Knowledge of the Freshwater Algae of Africa. 2. A First Report on the Freshwater Algae, mostly from the Cape Peninsula, in the Herbarium of the South Africa Museum," Annals South African Museum, **9,** pp. 483–611, 43 text-figs.

Fritsch, F. E., and Rich, F. (1924): "Contributions to our Knowledge of the Freshwater Algae of Africa. 4. Freshwater and Subaërial Algae from Natal," Trans. Roy. Soc. S. Afr., **11,** pp. 297–398, 31 text-figs.

Fritsch, F. E., and Rich, F. (1925): "Contributions to our Knowledge of the Freshwater Algae of Africa. 5. On a Deposit of Diatomaceous Earth from Ermelo, Transvaal," Trans. Roy. Soc. S. Afr., **12,** pp. 277–284, 1 text-fig.

Fritsch, F. E., and Rich, F. (1929): "Contributions to our Knowledge of the Freshwater Algae of Africa. 7. Freshwater Algae (exclusive of Diatoms) from Griqualand West," Trans. Roy. Soc. S. Afr., **18,** pp. 1–92, 32 text-figs.

Fritsch, F. E., and Rich, F. (1929): "Contributions to our Knowledge of the Freshwater Algae of Africa. 8. Bacillariales (Diatoms) from Griqualand West," Trans. Roy. Soc. S. Afr., **18,** pp. 93–123, 11 text-figs.

Fritsch, F. E., and Stephens, E. (1921): "Contributions to our Knowledge of the Freshwater Algae of Africa. 3. Freshwater Algae (exclusive of Diatoms), mainly from the Transkei Territories, Cape Colony," Trans. Roy. Soc. S. Afr., **9,** part 1, pp. 1–72, 29 text-figs.

GAUTHIER-LIÈVRE, H. (1924): "Schizophycées littorales de la petite Syrte (Tunisie) récoltées par M. Seurat au cours de ses derniers voyages (1922–1923)," Bull. Soc. Hist. natur. Afrique du Nord, **15,** pp. 129–130.
GAUTHIER-LIÈVRE, H. (1924): "Algues et Schizophycées de l'Afrique du Nord," *ibid.*, pp. 130–137.
GEITLER, L. (1925): "Cyanophyceæ," in A. Pascher's Süsswasserflora Deutschlands, Österreichs und der Schweiz, Heft 12, 450 pp., 560 text-figs.
GOMONT, M. (1893): "Monographie des Oscillariées," Annales Sciences natur., 7e série, Botanique, **15,** pp. 1–107, t. 6–14; **16,** pp. 111–284, t. 1–7.
HANSGIRG, A. (1890): "Über neue Süsswasser- und Meeres-Algen und Bacterien," Sitzungsbericht königl. böhm. Gesellsch. d. Wissenschaften. Math.-Naturw. Kl., **1,** pp. 3–34, t. 1–2.
HARIOT, P. (1895): "Liste des Algues recueillies au Congo par M. H. Lecomte," Journ. botan., **9,** pp. 242–244.
HARIOT, P. (1909): "Sur une collection d'algues recueillies au Maroc par M. Buchet," Bull Mus. Hist. nat. Paris, **15,** pp. 128–130.
HARIOT, P. (1913): "Quelques Cryptogames du Sahara et des régions voisines," *ibid.*, **19,** pp. 113–115.
HARIOT, P. (1913): "Algues d'eau douce du Maroc.," Bull. Soc. bot. France, **60,** pp. 40–43.
HEERING, W. (1914): "Ulothricales, Microsporales, Oedogoniales," in A. Pascher's Süsswasserflora Deutschlands, Österreichs und der Schweiz, Heft 6, 250 pp., 384 text-figs.
HENRIQUES, J. (1886): "Contribuçoes para o estudo da Flora d'Africa. Algæ," Bol. Soc. Broter, **4.**
HIERONYMUS, G. (1895): "Algae," in A. Engler's Die Pflanzenwelt Ostafrikas und der Nachbargebiete, Teil C, pp. 8–24.
HIRN, K. (1900): "Monographie und Iconographie der Oedogoniaceen," Acta. Soc. scient. Fennicæ, **27,** 395 pp., t. 1–64.
HIRN, K. (1906): "Studien über Oedogoniaceen I," Acta Soc. scient. Fennicae, **34,** 63 pp., t. 1–4.
HODGETTS, W. J. (1925): "Contributions to our Knowledge of the Freshwater Algae of Africa. 6. Some Freshwater Algae from Stellenbosch, Cape of Good Hope," Trans. Roy. Soc. S. Afr., **13,** pp. 49–103.
HUBER-PESTALOZZI, G. (1929): "Das Plankton natürlicher und künstlicher Seebecken Südafrikas," Atti del Congr. intern. Limnol. teor. ed appl., 1927, Roma, pp. 343–390, 6 text-figs.
HUBER-PESTALOZZI, G. (1930): "Algen aus dem Knysnawalde in Südafrika," Zeitschr. f. Botanik, **23,** Festschrift zum 70. Geburtstage von Friedrich Oltmanns, pp. 443–480, 8 text-figs.
HUSTEDT, FR. (1910): "Beitrag zur Algenflora von Afrika. Bacillariales aus Dahome," Archiv f. Hydrobiol. u. Planktonkunde, **5,** pp. 365–382, t. 3.
HUSTEDT, FR. (1927-28-29): "Die Kieselalgen Deutschlands, Österreichs und der Schweiz mit Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete," L. Rabenhorst's Kryptogamenflora, **7,** Lief. 1, 1927, Lief. 2, 1928, Lief. 3, 1929.
JADIN, F. (1893): "Algues des Iles Mascareignes récoltées en 1890 (Nostocacées)," Bull. Soc. botan. France, **40,** sess. extraord., pp. 148–173.
KAUFMANN, P. (1897): "Sur le pretendu du Nil vert." Rev. d'Egypte, Caire, **4,** p. 113. (Not seen, *v.* J. Brunnthaler, 1914, pp. 219–220.)
KRIEGER, W. (1930): "Algenassoziationen von den Azoren und aus Kamerun," Hedwigia, **70,** pp. 140–156, t. 4–6.
LAGERHEIM, G. (1882): "Bidrag til kännedomen om Stockholmstraktens Pediastréer, Protococcacéer och Palmellacéer," Öfversigt Kongl. Vetensk.-Akad. Förhandl., Nr. 2.
LAGERHEIM, G. (1893): "Chlorophyceen aus Abessinien und Kordofan," La Nuova Notarisia, **4,** pp. 153–166.
LEMMERMANN, E. (1898): "Beiträge zur Kenntniss der Planktonalgen I (Golenkinia, Richteriella, etc.)," Hedwigia, **37,** pp. 303–312, t. 10, 4 text-figs.
LEMMERMANN, E. (1898): "Beiträge zur Kenntniss der Planktonalgen II," Botan. Centralbl., **76,** pp. 150–156.
LEMMERMANN, E. (1899): "Das Phytoplankton sächsischer Teiche," Forschungsber. Biolog. Stat. Plön, **7,** pp. 96–135, t. 1–2.
LEMMERMANN, E. (1901): "Das Phytoplankton des Rych und des Greifswalder Boddens," Ber. Deut. Botan. Gesell., **19,** pp. 85–95, t. 4.
LEMMERMANN, E. (1910): Algen, III. Band in Kryptogamenflora der Mark Brandenburg, 712 pp. Many figs. in the text.
LEMMERMANN, E. (1913): "Eugleninae," in A. Pascher's Süsswasserflora Deutschlands, Österreichs und der Schweiz, Heft 2, Flagellatae 2, pp. 115–174, 198 text-figs.
LEMMERMANN, E. (1914): "Algae," in Wissensch. Erg. Deuts. Zentral-Africa-Exp. 1907–1908, **2,** Botanik, pp. 89–94.
LEMMERMANN, E. (1915): "Tetrasporales," in A. Pascher's Süsswasserflora Deutschlands, Österreichs und der Schweiz, Heft 5, pp. 21–51, 33 text-figs.
LINDEMANN, E. (1918): "Untersuchungen über Süsswasserperidinéen und ihre Variationsformen," I in Archiv f. Protistenkunde, **39,** pp. 209–262, t. 17, 144 text-figs.; II in Archiv f. Naturgesch., **84,** Abt. A, pp. 121–194, 200 text-figs.
MIGULA, W. (1898): Synopsis Characearum europaearum.
MONTAGNE, C. (1838): "Cryptogames algériennes," Ann. Sc. Natur., 2e série, **10,** pp. 268–279, 334–345, t. 8–9.
MÜLLER, O. (1899): "Bacillariaceen aus den Natronthälern von El Kab (Ober Aegypten)," Hedwigia, **38,** pp. 274–321 t. 10–12.
MÜLLER, O. (1903): "Bacillariaceen aus dem Nyassalande und einigen benachbarten Gebieten," Engler's bot. Jahrb., **34,** Erste Folge, 1903, pp. 9–38, t. 1–2; Zweite Folge, 1904, pp. 256–301, t. 3-4; Dritte Folge, **36,** 1905, pp. 137–205, t. 1–2; Vierte Folge, **45,** 1910, pp. 69–122, t. 1–2.
MUSCHLER, R. (1908): "Énumération des Algues marines et d'eau douce observées jusqu'à ce jour en Égypte," Mem. de l'Institut égyptien, **5,** pp. 141–237.
NAUMANN, E. (1925): "Ueber Nostoc elgonense n. sp., eine neue Art der Gattung Nostoc aus der Kratersee von Mount Elgon, Kenia Colony," Arkiv för Botanik, **19,** No. 15, 7 pp., 3 figs., 1 t.

NORDSTEDT, O. (1880): "De Algis et Characeis," Act. Univ. Lundens., **16**, pp. 1–20, t. 1.
NORDSTEDT, O. (1888): "Freshwater Algae collected by Dr. S. Berggren in New Zealand and Australia," K. Sv. Vet.-Akad. Handl., **22,** 97 pp., 7 t.
NORDSTEDT, O. (1888): "Conjugatae," Forschungsr. S. M. S. "Gazelle," IV Theil, pp. 3–4.
NORDSTEDT, O. (1897): "Sötvattensalger fran Kamerun," Botaniska Notiser, pp. 131–133.
NYGAARD, G. (1926): "Plankton from two Lakes of the Malayan Region," Videnskab. Medd. Dansk Naturh. Forening Köbenhavn, **82,** pp. 197–240, t. 1–8.
NÄGELI, C. (1849): "Gattungen einzelliger Algen," 139 pp., 8 t.
OSTENFELD, C. H. (1908): "Phytoplankton aus dem Victoria Nyanza," Engler's bot. Jahrb., **41,** pp. 330–350, 2 text-figs.
OSTENFELD, C. H. (1909): "Notes on the Phytoplankton of Victoria Nyanza, East Africa," Bull. Mus. Comp. Zool., Harv. College, **52,** pp. 171–181, t. 1–2.
OSTENFELD, C. H., and NYGAARD, G. (1925): "On the phytoplankton of the Gatun Lake, Panama Canal," Dansk Botan. Arkiv, **4,** No. 10, pp. 1–16, 20 text-figs.
PASCHER, A. (1913): "Chrysomonadinae, Cryptomonadinae und Chloromonadinae" in A. Pascher's Süsswasserflora Deutschlands, Österreichs und der Schweiz, Heft 2, Flagellatae 2, pp. 1–114, 175–181, 180 text-figs.
PASCHER, A. (1927): "Volvocales," *ibid.*, Heft 4, 506 pp., 451 text-figs.
PRINGSHEIM, N. (1860): "Beitrage zur Morphologie und Systematik der Algen. III. Die Coleochaeteen," Pringsheim's Jahrb., **2.**
PRINTZ, HENRIK (1913): "Eine systematische Uebersicht der Gattung Oocystis Nägeli," Nyt Magazin for Naturv., **51,** pp. 165–203, t. 4–6.
PRINTZ, HENRIK (1915): "Beiträge zur Kenntnis der Chlorophyceen und Ihrer Verbreitung in Norwegen," Kongl. Norske Vidensk. Selsk. Skr., No. 2, pp. 1–76, t. 1–4.
PRINTZ, HENRIK (1920): "Subaërial Algae from South Africa," Kongl. Norske Vidensk. Selsk. Skr., Nr. 1, pp. 1–41, t. 1–14.
PRINTZ, HENRIK (1927): "Chlorophyceae (nebst Conjugatae, Heterocontae und Charophyta)," 3. Band der zweiten Auflage von A. Engler und K. Prantl: Die natürlichen Pflanzenfamilien. 463 pp., 366 text-figs.
RATTRAY, J. (1889): "A Revision of the Genus Coscinodiscus and some Allied Genera," Proc. Roy. Soc. Edinburgh, **16,** pp. 449–692.
REINSCH, P. (1878): "Freshwater Algae from the Cape of Good Hope (Contributiones ad floram Algarum aquae dulcis Promontorii Bonae Spei)," Journ. Linn. Soc. Bot., **16,** pp. 232–248, t. 6.
SAUVAGEAU, C. (1892): "Les algues d'eau douce récoltées en Algérie," Bull. Soc. Bot. France, **39,** pp. 104–128, t. 6.
SAUVAGEAU, C. (1895): "Sur le Radaisia, nouveau genre de Myxophycée," Journ. de Botan., **9,** pp. 372–376, t. 7.
SAUVAGEAU, C. (1897): "Algues," in N. Patouillard's Catalogue raisonné des plantes cellulaires de la Tunisie. Exploration scientifique de la Tunisie, pp. 16–19.
SCHERFFEL, A. (1910): "Rhaphidonema brevirostre nov. spec., zugleich ein Beitrag zur Schneeflora der Hohen Tatra," Botan. Közl., **9, 2,** pp. 116–123, 5 text-figs.
SCHINZ, H. (1906): "Plantae Menyhardtianae. Ein Beitrag zur Kenntnis der Flora des unteren Sambesi," Denkschr. K. Akad. Wiss. Wien, **78** pp. 364–445 (Algae, pp. 390–392).
SCHMIDLE, W. (1898): "Die von Professor Dr. Volkens und Dr. Stuhlmann in Ost-Afrika gesammelten Desmidiaceen," Engler's bot. Jahrb., **26,** pp. 1–59, t. 1–4.
SCHMIDLE, W. (1899): "Über Planktonalgen und Flagellaten aus dem Nyassa-See," Engler's bot. Jahrb., **27,** pp. 229–237, 8 text-figs.
SCHMIDLE, W. (1900): "Drei interessante tropische Algen," Botan. Centralblatt, **81,** pp. 417–418.
SCHMIDLE, W. (1900): Algen, in "Die von W. Goetze und Dr. Stuhlmann in Ulugurugebirge, sowie die von W. Goetze in der Kisaki- und Khutu-Steppe und in Uhehe gesammelten Pflanzen," Engler's bot. Jahrb., **28,** pp. 333–334.
SCHMIDLE, W. (1901): "Beiträge zur Algenflora Africas," Engler's bot. Jahrb., **30,** pp. 58–68, t. 2.
SCHMIDLE, W. (1901): "Schizophyceae, Conjugatae, Chlorophyceae in A. Engler: Ber. ü. d. botan. Ergeb. d. Nyasa-See- und Kinga-Gebirgs-Exp. IV. (Tropische afrikanische Thermalalgenflora)," Engler's bot. Jahrb., **30,** pp. 240–253, t. 4–5.
SCHMIDLE, W. (1902): "Algen, insbesondere solche des Plankton, aus dem Nyassa See und seiner Umgebung, gesammelt von Dr. Fülleborn," Engler's bot. Jahrb., **32,** pp. 56–88, t. 1–3.
SCHMIDLE, W. (1902): "Das Chloro- und Cyanophyceenplankton des Nyassa und einiger anderer innerafrikanischer Seen," Engler's bot. Jahrb., **33,** pp. 1–33.
SCHODDUYN, R. (1926): "Matériaux pour l'étude de la Faune et la Flore des Eaux douces de Funchal (Madère)," Ann. Biol. lacustre, **15,** pp. 188–223, 7 text-figs.
SCHRÖDER, B. (1897): "Die Algen der Versuchsteiche des Schlesischen Fischereivereins zu Trachenberg," Forschungsber. Biol. Stat. Plön, **5,** pp. 29–66, t. 2.
SCHRÖDER, B. (1911): "Rhizosolenia victoriae n. sp.," Ber. Deut. Botan. Gesellsch., **29.**
SENN, GUSTAV (1899): "Ueber einige koloniebildende einzellige Algen," Botan. Zeitung, **57,** pp. 39–104, t. 2–3.
SKUJA, H. (1926): "Vorarbeiten zu einer Algenflora von Lettland, I," Acta Horti Botan. Univ. Latviensis, **1,** pp. 33–54, 4 (55) text-figs.
SKUJA, H. (1927): "Vorarbeiten zu einer Algenflora von Lettland, III," Acta Horti Botan. Univ. Latviensis, **2,** pp. 51–116, t. 1–2.
SKVORTZOW, B. W. (1928): "Die Euglenacéengattung Phacus Dujardin. Eine systematische Übersicht," Ber. Deut. Botan. Gesellsch., **46,** pp. 105–125, t. 2.
SMITH, G. MORGAN (1916): "A Monograph of the Algal Genus Scenedesmus, Based upon Pure Culture Studies," Trans. Wisconsin Acad. Sc. Arts and Lett., **18,** Part II, pp. 422–530, t. 25–33.

SMITH, G. MORGAN (1920): "Phytoplankton of the Inland Lakes of Wisconsin, I," Wisc. Geol. Nat. Hist. Survey, **57**, pp. 1–243, t. 1–51.

VAN HEURCK, H. (1884): Synopsis des Diatomées de Belgique. Anvers.

VAN OYE, P. (1924): "Écologie des épiphytes des troncs d'arbres au Congo Belge," Rev. gén. Botan., **36**, pp. 481–498, 1 text-fig.

VAN OYE, P. (1927): "Over de Wierflora van Belgisch-Kongo," Botan. Jaarboek, **20**, pp. 93–144. (Not seen.)

VAN OYE, P. (1927): "Données concernant la distribution géographique des Algues au Congo belge," Rev. zool. africaine, **15**, pp. 19–33. (Not seen.)

WEHRLE, E. (1927): "Studien über Wasserstoffionenkonzentrationsverhältnisse und Besiedelung an Algenstandorten in der Umgebung von Freiburg i. Br.," Zeitschr. f. Botanik, **19**, pp. 209–287, 9 Abb.

WESENBERG-LUND, C. (1904–1908): Plankton Investigations of the Danish Lakes, I–II, Copenhagen.

WEST, W., and G. S. (1895): "A Contribution to our Knowledge of the Freshwater Algae of Madagascar," Trans. Linn. Soc. Bot., 2 Ser., **5**, Part II.

WEST, W., and G. S. (1896): "Algae from Central Africa," Journ. of Botany, **34**, pp. 377–384, t. 361.

WEST, W., and G. S. (1897): "Welwitsch's African Freshwater Algae," Journ. of Botany, **35**, 78 pp., t. 365–370.

WEST, W., and G. S. (1904–1923): A Monograph of the British Desmidiaceae, I–IV. Printed for the Ray Society, Vol. V. by West and Carter. 167 plates.

WEST, G. S. (1904): "A Treatise on the British Freshwater Algae," 372 pp., 1 plate, 166 figs.

WEST, G. S. (1907): "Report on the Freshwater Algae incl. Phytoplankton of the Third Tanganyika Expedition," Journ. Linn. Soc. Bot., **38**, pp. 81–197, t. 2–10.

WEST, G. S. (1909): "The Algae of the Birket Qarun, Egypt," Journ. of Botany, **47**, pp. 237–244, t. 498, figs. 2–4, 8–17.

WEST, G. S. (1909): "Phytoplankton from the Albert Nyanza," Journ. of Botany, **47**, pp. 244–246, t. 498, figs. 1, 5–7, 18.

WEST, G. S. (1910): "Some New African Species of Volvox," Journ. Quekett Microsc. Club., Ser. 2, **11**, pp. 99–104, t. 3.

WEST, G. S. (1912): "Freshwater Algae," Ann. South Afr. Mus., **9**, pp. 61–90, t. 1–2.

WEST, G. S. (1918): "A Further Contribution to our Knowledge of the two African Species of Volvox," Journ. Quekett Microsc. Club, Ser. 2, **13**, pp. 425–428, t. 29–30. (Not seen.)

WILDEMANN, E. DE (1889): "Quelques mots sur la flore algologique du Congo," Bull. Soc. roy. botan. Belgique, **28**, 2, pp. 6–10.

WILDEMANN, E. DE (1889): "Encore quelques mots à propos de l'Hansgirgia flabelligera De Toni," Bull. Soc. roy. botan. Belgique, **28**.

WILLE, N. (1903): "Ueber einige von J. Menyhardt in Südafrika gesammelte Süsswasseralgen," Oesterreich. botan. Zeitschr., pp. 1–7, 5 text-figs.

VIRIEUX, J. (1913): "Plankton du lac Victoria Nyanza," Voyage de Ch. Alluaud et R. Jeannel en Afrique Orientale, 1911–1912, Résultats scient., pp. 3–20, t. 1–2.

WOLLE, F. (1887): Freshwater Algae of the United States, Text, 364 pp., t. 55–211.

WOLOSZYNSKA, J. (1912): "Das Phytoplankton einiger javanischer Seen mit Berücksichtigung des Sawa-Planktons," Bull. Acad. Scienc. de Cracovie Cl. Sc. Math. et Natur., pp. 649–709, t. 33–36, 26 text-figs.

WOLOSZYNSKA, J. (1914): "Studien über das Phytoplankton des Victoriasees," Hedwigia, **55**, pp. 184–223, t. 2–8.

WOOD, H. C. (1874): "A Contribution to the History of the Freshwater Algae of North America," Smithson. Contrib. to Knowl., No. 241, **19**, 262 pp., t. 1–21.

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE FRESHWATER ALGAE OF AFRICA.*

10. *Phytoplankton from South African Pans and Vleis.*

By Florence Rich.†

(Communicated by Miss E. L. Stephens.)

(With twenty figures in the Text.)

A. Introductory Remarks.

Through the instrumentality of Miss E. L. Stephens of the University of Cape Town the samples of phytoplankton from South African pans and vleis, with which the present report deals, were placed at my disposal. They were collected mainly by Mrs. G. Evelyn Hutchinson (G. E. Pickford) whilst engaged with her husband in making a general survey of the fauna —especially the planktonic fauna—of the pans and other freshwaters of the Transvaal. Miss Stephens herself and Miss J. Schuurman also added to the collection. In the following paper much use has been made of a report drawn up by Mr. and Mrs. Hutchinson and Miss Schuurman ‡ in which the various pieces of water examined are described; many other details have also been supplied by Mrs. Hutchinson.

The following papers on African Phytoplankton have been previously published :—

Schmidle, W.—(1) " Algen, insbesondere solche des Plankton, aus

* From the Botanical Department, East London College, University of London. The last seven papers of this series have been published in these Transactions, beginning with No. 3 in Vol. IX for 1921. The author is indebted to the Carnegie Corporation for the Advancement of Research for a grant in aid of this work, made through the Research Grant Board of the Union of South Africa.

† This paper was practically completed when it was brought to my notice that Mr. G. Nygaard (of Copenhagen) had ready for publication an account of the Algae and Phytoplankton from certain Transvaal waters. I had the opportunity of seeing his manuscript, and found that, though among his samples seven were from the same localities as those submitted to me, there did not seem to be much overlapping. Naturally several species were common to the two papers, but the new varieties and forms described by me came mainly from a piece of water not examined by Mr. Nygaard. The paper is therefore submitted as it stands.

‡ These authors have in the press a detailed account of their investigations.

dem Nyassa-See und seiner Umgebung," Engler's Bot. Jahr., xxxii, 1902, pp. 56–88.

(2) " Das Chloro- und Cyanophyceenplankton des Nyassa und einiger anderer innerafrikanischer Seen," *ibid.*, xxxiii, 1902, pp. 1–33.

West, G. S.—" Report on the Freshwater Algae, including Phytoplankton, of the Third Tanganyika Expedition," Journ. Linn. Soc. London. Bot., xxxviii, 1907, pp. 81–197.

Ostenfeld, C. H.—" Phytoplankton aus dem Victoria Nyanza," Engler's Bot. Jahr., xli, 1908, pp. 330–350.

West, G. S.—" Phytoplankton from the Albert Nyanza," Journ. Bot., July 1909.

Woloszynska, J.—" Studien über das Phytoplankton des Victoriasees," Hedwigia, lv, 1914, pp. 184–223.

Huber-Pestalozzi, G.—" Das Plankton natürlicher und künstlicher Seebecken Südafrikas," Verhand. Internat. Ver. f. theoret. u. angew. Limnologie, iv, 1929, pp. 343–390.

The completion of the present work was held back in expectation of the appearance of the last-named paper, which became available early in 1930. There was, however, not much overlapping in the collections; the only pieces of water common to Dr. Huber's and the one now under consideration being Lake Chrissie, Blaauwater, and the Hartebeestpoort Dam. The seasons, moreover, were different, for while his collections were made in Spring—September, October, November (1926)—these were made chiefly from January to May (1928).

Samples from 38 pieces of water were examined, from which 262 species and varieties were obtained. Of these, 9 species and 8 varieties are new (and there are several new forms). The phytoplankton of the South African waters examined is, in general, poor. A noteworthy exception is the Weltevreden West Pan, where a great number of species and varieties (more than 100) occurred, though but few of them were represented by any considerable number of individuals. The collectors note that this pan differs from all others investigated in the Transvaal in having pure, clear, slightly acid water. (Pure, clear, slightly acid water is associated with a scanty plankton in the five mountain-top reservoirs of the south-west Cape represented in these samples, but their comparatively recent construction and isolated position may account for this.)

These pans * or vleis are shallow, saucer-like, circular or kidney-shaped depressions, usually with no outlet or only a temporary overflow one, varying in size from small depressions a few yards across to large basins

§ " Pan " is the name given to them in the Transvaal; " vlei " in Cape Colony. A " kuil " is a pot-hole in a river-bed, or other usually permanent and (generally) small, deep piece of water.

several square miles in area. They may be filled with water either temporarily or permanently. Temporary pans dry up completely or almost completely during the dry season, and fill up again with the rains that begin about May at the Cape and November in the Transvaal. Those that on drying leave a rich terrestrial vegetation are known locally as Grass Pans (such are Rietfontein and Brakpan I), while those that do not leave much vegetation may be styled Mud Pans (such are Brakpan II, Eliazer Pan, and Potchefstroom Dam).

The permanent pans of the Transvaal contain water that is generally from pale yellow to deep sepia in colour; many, on the addition of acid, give a strong precipitate consisting largely of colloidal silica (such are Lake Chrissie and Blaauwater). The chemical conditions are very variable, and this is reflected in corresponding differences in their fauna and flora. For some, but by no means all, of the pans, details have been furnished of the physical and chemical features, but it is difficult at this distance to find any correlation between these and the nature and abundance of the plankton, as most of the samples have been divided before being sent to England; the collectors on the spot are in a much better position for forming a true conception of this.

The hydrogen-ion concentration varied from pH 6·7 (in Rietfontein I and II and Brakpan I) to pH 9·2 (in Blaauwater and Eliazer Pan), but no connection could be traced between this and the character of the phytoplankton; its influence is evidently modified by other factors.

The salinity of the permanent pans was very variable; every gradation was said to occur from fresh to saturated salt water, though no pans were investigated with a salinity of more than ·23 N. In Banagher III, the pan with the highest salinity, the phytoplankton consisted almost entirely of quantities of *Nodularia spumigena* var. *vacuolata*. With this pan it is of interest to compare Lakes Elmenteita and Nakuru, in the Rift Valley, Kenya, which have salinities of ·22 N. and ·27 N.* respectively, and where the abundant plankton consists almost exclusively of another Blue-Green Alga, *Arthrospira Platensis* (Nordst.) Gomont. This probably simply means that in these saline waters other Algae cannot grow, and the Blue-Greens with their well-known power of being able to withstand extreme conditions are free from competition.

The freshest water (salinity not exceeding ·0015 N.) was found in Rietfontein I and II, Brakpan, Weltevreden East and Weltevreden West, and it is this last-named piece of water that contained the richest phytoplankton of the collection. It has just been noted that Blue-Green Algae were plentiful where the salinity was high, but it was found that they also occurred in pans of low salinity (Brakpan I, Weltevreden East and West);

* P. M. Jenkin. Letter to Nature, 12th October 1929.

they were not, however, found in pans where the phosphate content was high (1–6 pts. per million), as in Lake Chrissie, Banagher, Blaauwater, and Eliazer Pan.

A general account of the vegetation and other characteristics of the different types of fresh waters in the neighbourhood of Cape Town will be found in " The Botanical Features of the South-West Cape " (Specialty Press, Wynberg, Cape). It should be noted that Mrs. Hutchinson collected near Cape Town only during the dry season, and consequently her samples are nearly all from permanent vleis and reservoirs, which are far poorer in all forms of aquatic vegetation than the temporary pools and vleis formed during the rainy season. In these temporary waters a rich and varied algal flora develops.

With regard to periodicity there is not much to be said ; the only piece of water from which monthly samples were regularly collected over a period of nearly a year is Florida Lake, and (although 40 species and varieties were observed) these samples were so very scanty that it is impossible to draw useful conclusions. It appears, however, that *Peridinium tabulatum*, which is always present in the Lake, is rather common from May to August and less common from September to April. *Microcystis flos-aquae*, another Alga regularly present in this lake, was slightly more common from October to April than from May to September.

The occurrence of *Pleodorina californica*, observed by Mrs. Hutchinson in Weltevreden West Pan, is noteworthy, as this genus has not before been recorded from South Africa. Of the Chlorococcales, *Pediastrum* is a well-represented genus, occurring plentifully in several pieces of water. The typically planktonic *Westella botryoides* was found in Leeuwkraal, Kuil III (Heidelberg). *Scenedesmus* was common, with several species, often in some abundance. *Coelastrum* was fairly well represented, specially in Brakpan. Two species of *Bulbochaete* were observed in the fruiting condition. Among the Desmidiaceae *Euastrum* played a minor rôle ; *Cosmocladium constrictum* in Weltevreden West is an interesting record ; filamentous Desmids were present in this same pan in some quantity ; they also occurred in Lake Chrissie, Kuil II, and Florida Lake. No zygospores were found except in the case of *Closterium lineatum* and *Cosmarium pygmaeum*. Thirty species and varieties of *Cosmarium* and twenty-nine of *Staurastrum* were observed.

The Heterokontae were mainly represented by *Botryococcus Braunii*.

Of the Chrysophyceae only *Mallomonas alpina* and *Dinobryon divergens* were observed. The absence of the genus *Dinobryon* (one of the dominant features of the plankton of many European lakes) from the plankton of Lake Nyasa, Victoria Nyanza, and Lake Tanganyika was commented on in 1907 by G. S. West, who suggested that it might be due to the tempera-

ture of the water being too high ; the species of this genus appear to attain their maximum in the European plankton at a temperature below 15° C., and the mean temperature of Tanganyika is given as 24·7° C. ; of the two localities in which it has now been found temperature records are available only for one, Weltevreden West, and Mrs. Hutchinson gives for this 15° C. on 15th May and 12° C. in July (1898), thus more or less bearing out West's suggestion.

The number of Diatoms in the samples was not large, but in a few cases the phytoplankton consisted almost entirely of Diatoms (Florida Lake, Rietkuil, Weltevreden East, and Lakeside Vlei). G. S. West commented on the absence of *Tabellaria* from the plankton examined by him ; in the present collection *Tabellaria flocculosa* was found in two pieces of water. *Melosira granulata* and its variety *angustissima* occurred in enormous quantities in Weltevreden East and were common in other pieces of water.

Of the Dinoflagellates at least two species of *Peridinium* were present, and in some quantity.

The Euglenineae were fairly well represented, but were never abundant.

Dr. Huber-Pestalozzi remarks on the small number of Cyanophyceae that he found ; in the present collection they were common, though not very well represented. *Microcystis flos-aquae* was quite common, and *Nodularia spumigena* var. *vacuolata* was abundant in, and formed almost the sole constituent of, the plankton of Banagher Pan III.

The very grateful thanks of the writer are offered to Professor F. E. Fritsch of the University of London for his advice, encouragement, and helpful criticism.

B. Enumeration of the Samples.

The following is a list, alphabetically arranged under three main districts, of the pieces of water from which plankton was collected, with a brief description of each (where available) and the names of the principal algal constituents of the plankton. Numbers are given to the samples to facilitate reference.

The collections were made over a period extending from July 1927 to July 1928 (inclusive). The two principal collectors are distinguished by the initials G. E. H. and J. S.

1. *Transvaal.*

1. *Lake Banagher* (near edge). 28.5.28. G. E. H.

A large permanent pan, 10 to 20 feet deep, the water grey and turbid with colloidal silica, very slightly brackish. pH about 9. *Potamogeton Livingstonei.* Zooplankton : *Diaptomus* sp. together with *Lovenula* sp. and *Daphnia Thomsoni.* Phytoplankton : sterile *Oedogonium.*

2. *Banagher Pan II.* 28.5.28.

A small, shallow, very slightly brackish pan. Water pale brown, slightly turbid. pH, 8·6. Macrovegetation rich (*Scirpus*). Zooplankton rich (*Cyclops, Daphnia*). Nothing algal except a very few Diatoms (*Navicula, Amphora*).

3. *Banagher Pan III.* (Misnamed Knochdhu.) 18.5.28. G. E. H.

More or less permanent, about half a square mile in area, very shallow (only about 1 foot). Water greenish brown, turbid. pH, 9·1. High salt content (·23 N.). Macrovegetation absent. Zooplankton consisting of Ostracods. Enormous quantities of *Nodularia spumigena* var. *vacuolata*.

4. *Barberspan* (middle of lake), South West Transvaal. 6.4.28 and 7.6.28. G. E. H.

A large, sub-permanent pan, on calcareous tufa, very slightly brackish. Water clear. pH, 9·1. Some Charophytes grow in this pan, but they are not abundant. Zooplankton: three species of *Cladocera*, a cyclopoid Copepod and various Rotifers, *Botryococcus protuberans*, *Microcystis pulverea*, *Pediastrum Boryanum*, *P. simplex* var. *duodenarium*, *Oocystis* sp. The pH and chloride content are almost identical with those of Lake Chrissie, but the water contains no colloidal silica. The fauna is strikingly different, fish and crabs being abundant in Barberspan, but practically absent from Lake Chrissie.

5. *Blaauwater*, near L. Chrissie, Eastern Transvaal. 27.2.28. G. E. H.

Turbid, brown water containing colloidal silica, slightly brackish. pH, 9. Macrovegetation absent. Zooplankton: *Diaptomus*, *Lovenula*. Phytoplankton poor, represented merely by a few Diatoms. The authors of the report referred to above say that this is one of a series of pans which may be considered a special type of shallow, alkaline lake, "the food supply of the fauna being almost entirely derived from the dried inflorescences of a species of grass blown in from the surrounding veld."

6. *Brakpan I.* February, March, April, May, June, and November, 1928. G. E. H. and J. S.

Slightly turbid, yellowish water, fresh. pH above 7. Macrovegetation rich. Zooplankton: *Conochilus* and Copepods. *Volvox* (2 spp.), *Zygnema*, *Spirogyra*, *Pediastrum* (2 spp.), *Scenedesmus* (4 spp.), *Actinastrum Schroeteri*, *Coelastrum* (2 spp.), *Eudorina*, a few Diatoms.

7. *Brakpan II.* 6.5.28. G. E. H.

Volvox sp.

8. *Brakpan*, on damp soil. No. 27. D. Weintroub.

Mainly *Gomphosphaeria aponina*.

9. *Lake Chrissie.* 26.2.28 and 19.5.28. G. E. H.

The largest natural body of water in South Africa. A permanent pan, about 3 miles long, 10 to 20 feet deep, with flat rock bottom. Other particulars the same as in Lake Banagher. Phytoplankton scanty; two

or three species of *Oedogonium* with epiphytic Diatoms (*Gomphonema, Amphora*), *Botryococcus Braunii.*

10, 11. *Kuil I, Kuil II.* 19.5.28. G. E. H.

Two small pools in a dry stream-bed quite near the lake.

Kuil I contains a little vegetative *Volvox.*

Kuil II contains *Oedogonium* sp., *Spirogyra* sp., a few Diatoms, and a few Desmids.

12. *Eliazer Pan.* (Pond below spring.) 27.5.28. G. E. H.

A seasonal " mud pan," 1 square mile or less in area, very shallow. Water very turbid, very slightly brackish. pH, 8·3–9·2. Very little macrovegetation. Zooplankton: Phyllopods and Copepods.

Volvox, 2 spp., very common.

13. *Florida Lake* (see Introductory Remarks, pp. 152, 153). Six monthly samples from July 1927 to January 1928, April and May 1929. J. S.

This is really a mine dam formed out of what was once a stream in a hollow. Relatively permanent, no colloidal silica, fresh water. A Scirpus pan. Not much phytoplankton received, mainly *Melosira ambigua.* Amongst other Algae present in small quantity, *Peridinium tabulatum, Microcystis flos-aquae, Pediastrum duplex, P. tetras, Anabaena affinis, Kirchneriella obesa* var. *aperta, Dictyosphaerium pulchellum, Dinobryon divergens, Staurastrum* spp., and a few Flagellates.

14. *Frischgewaagd Dam* (near Trichard Station). 27.2.28. J. S.

Euglena oxyuris f. *minor, Anabaena spiroides, Microcystis flos-aquae, Pediastrum simplex* var. *duodenarium*, and others.

15. *Hartebeestpoort Dam.* 29.4.28. G. E. H.

Peridinium cinctum, Microcystis flos-aquae, mainly.

16. *Johannesburg Zoo.* No. 52. 14.3.28.

Microcystis flos-aquae mixed with indeterminate masses.

17. *Klippoortje Dam* (Heidelberg, S. Transvaal). 7.4.28. J. S.

Botryococcus Braunii and *B. protuberans, Phacus longicauda, Euglena oxyuris* f. *minor, Pediastrum duplex* var. *asperum*, and a few Diatoms.

18. *Leeuwkraal* (Heidelberg, S. Transvaal). J. S.

Kuil, scarcely anything algal.

19. *Kuil III. Eudorina elegans, Westella botryoides, Sphaerocystis Schroeteri.*

20. *Dam. Eudorina elegans*, very rare.

21. *Potchefstroom Dam* (near Johannesburg). 1.10.27. J. S.

Peridinium tabulatum, Staurastrum spp., *Pediastrum simplex* var. *duodenarium, Phacus longicauda, Melosira granulata.*

22. *Rietfontein.* 12.1.28 and 23.2.28. G. E. H.

A " grass pan " near Johannesburg. A temporary neutral pan of low salinity. Water yellowish, slightly turbid. pH, 6·7–7·2. Macrovegetation

rich. Zooplankton: *Conochilus* and Copepods. *Volvox* sp., *Eudorina elegans*, *Closterium* spp., *Pearsoniella variabilis*, *Synedra* sp.

23. *Rietkuil* (Bethal District, E. Transvaal). 25.2.28. M. E. Blenkiron and D. Weintroub.

Anabaena spiroides, *Melosira granulata* var. *angustissima*, mainly.

24. *Weltevreden East Pan.* 8.7.28.

Close to Lake Chrissie in the Ermelo District. About one quarter of a square mile in area. Permanent. Water slightly turbid and coloured. fresh. Very little silica, "less than its normal value." pH, 8·0. *Microcystis flos-aquae*, *Melosira granulata*, *Pediastrum Boryanum*, *P. duplex* var. *reticulatum*, and others.

25. *Weltevreden West Pan.* 19.5.28, M. E. Blenkiron; and 8.7.28, G. E. H.

In the Lake Chrissie area. By far the most important of these pieces of water from the algological point of view. About one quarter of a square mile in area. Permanent. No colloidal silica. Remarkable among these pieces of water in having pure, clear, fresh water; pH, 6·8. Macrovegetation rich. Zooplankton: Cyclopoid and Ostracods. Phytoplankton very rich and varied. Desmids (species of *Closterium*, *Pleurotaenium*, *Euastrum*, *Micrasterias*, *Cosmarium*, *Arthrodesmus*, *Staurastrum*, *Cosmocladium*, *Sphaerozosma*, *Onychonema*, *Hyalotheca*, *Desmidium*), *Volvox*, *Pleodorina*. Diatoms, *Oedogonium*, *Bulbochaete*, *Dinobryon divergens*, *Peridinium tabulatum*, *Euglena oxyuris* f., *Coelosphaerium Kützingianum*, and others.

2. *Neighbourhood of Cape Town* (see *ante*, pp. 152, 153).

26. *Alexandra Reservoir*, Table Mountain. 22.1.28. G. E. H.

Botryococcus Braunii.

27. *De Villiers Reservoir*, Table Mountain. 22.1.28. G. E. H.

Botryococcus Braunii, a little *Scytonema* sp. intermingled with *Gloeocapsa* sp.

28. Pool in *Echo Valley*, Table Mountain. 22.1.28. G. E. H.

Moss protonema and debris, fragments of *Oedogonium*.

29. *Lakeside Vlei* (=Sand Vlei, Muizenberg Vlei), Cape Flats. 27.11.27 and 1.2.28. G. E. H.

"Not permanent, approximately neutral, slightly brackish." *Cladophora glomerata* (?) covered with epiphytic Diatoms and young *Oedogonium* plants. The Diatoms present are decidedly marine.* *Chaetoceros* sp. is

* Miss E. L. Stephens tells me: "This vlei is divided by a railway embankment into two portions, the eastern of which is connected with the sea at one point and contains *Ruppia* and other brackish-water aquatics, while the western part has typical freshwater plants and Algae (*Volvox*, etc.)." This sample evidently must have been taken from the eastern portion.

abundant, together with a *Cocconeis* and an *Achnanthes*; other Diatoms mostly rare.

30. *Princess Vlei*, Cape Flats. 17.1.28 and 5.2.28. G. E. H.

" Permanent. No colloidal silica. Slightly brackish." *Scenedesmus protuberans, Micractinium pusillum.*

31. *Ronde Vlei*, Cape Flats. 20.1.28 and 5.2.28. G. E. H.

" Thick-looking water. Salinity about half that of sea-water." *Hormidium* sp., *Oocystis Borgei, O. rupestris*, etc., and Diatoms (*Cyclotella, Campylodiscus, Rhopalodia, Epithemia, Cocconeis*).

32. *Steenbras Reservoir*, Hottentot Holland Mts. 7.1.28. G. E. H.

A very small sample was submitted and very little algal growth was found. *Micrasterias rotata* var. *pulchra, M. denticulata* var. *angulosa, Closterium setaceum, Cl. stellenboschense*, Diatoms (*Tabellaria, Eunotia, Navicula*), *Pleurotaenium Ehrenbergii* var. *elongatum.*

33. *Victoria* (*Upper Wynberg*) *Reservoir*, Table Mountain. 15.1.28. G. E. H.

Very little algal growth. Fragments of *Stigeoclonium* sp.

34. *Woodhead Reservoir.* Collector says this sample was contaminated from Lakeside Vlei; it was, therefore, not examined very extensively.

35. *Zeekee Vlei*, Cape Flats. 5.2.28. G. E. H.

Permanent, no colloidal silica, slightly brackish.

Hormidium sp., *Microcystis flos-aquae, Chroococcus dispersus, Aphanothece conglomerata*, Diatoms.

3. *Portuguese East Africa.**

36. *Marramwe Lake.* 14.6.28. E. L. Stephens.

A large lake with turbid water and no macrovegetation.

Chroococcus minutus, Campylodiscus clypeus.

37. *Maloti Lake*, near Masiyeni, S. Chopiland. 7.6.28. E. L. Stephens.

A medium-sized lake with turbid water and very little macrovegetation.

Microcystis flos-aquae, Botryococcus Braunii (forming brick-red granules).

38. *Matsumé Lake*, near Masiyeni, S. Chopiland. 27.6.28. E. L. Stephens.

A small lake with clear water and rich macrovegetation.

A considerable amount of débris amongst which were scattered at rare intervals many different species of which only one or two individuals could be found. Desmids (*Closterium, Pleurotaenium, Euastrum, Micrasterias, Cosmarium, Staurastrum*), Diatoms, *Bulbochaete* spp., *Oedogonium, Coelastrum cambricum* forma, *Pediastrum duplex* var. *asperum, Dimorphococcus lunatus* (an isolated group), *Peridinium* sp.

* This material was collected during a botanical expedition to Portuguese East Africa, assisted by the University of Cape Town Staff Research Fund.

C. Systematic Enumeration of the Species Observed.*

(References to existing figures are usually given only in cases where the species has not previously been recorded in the plankton for this part of the world.)

CLASS I. ISOKONTAE.

GROUP. VOLVOCALES.

Series. Chlamydomonadales.

Genus Pandorina Bory.

Pandorina morum (Müll) Bory.

Sample 25 (rare).

Recorded from the plankton of Nyasa, but abundant in every part of Africa.

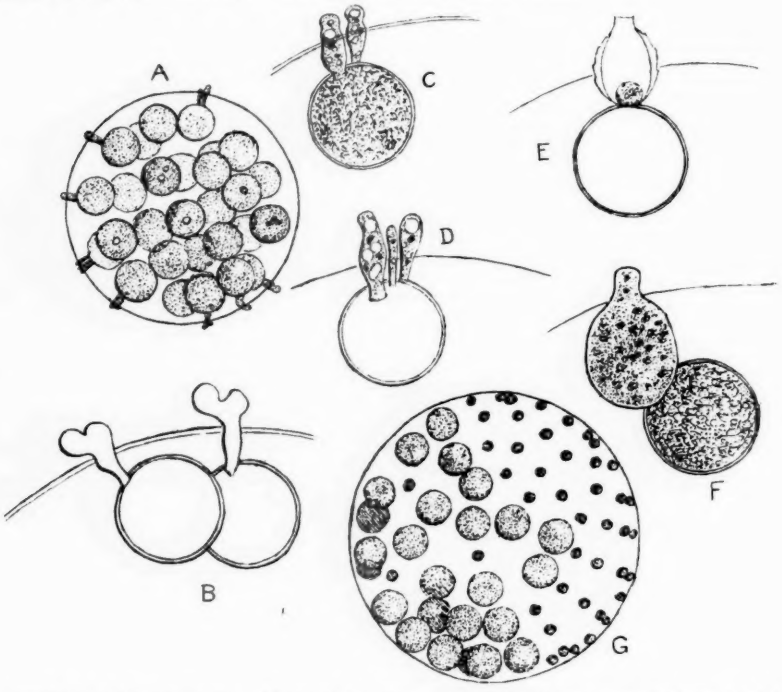


Fig. 1.—*A*, *Eudorina elegans* Ehrenb. with parasitic fungus. *B–F*, *Rhizophidium appendiculatum* (Zopf) Fischer, growing on *Eudorina* cells. *G*, *Pleodorina californica* Shaw. (*A*, × 370; *B–F*, × 1000; *G*, × 200.)

Genus Eudorina Ehrenberg.

Eudorina elegans Ehrenb.

Samples 6, 18, 22 (common), 24.

On the cells, in many cases, a parasite was observed, resembling a *Chamaesiphon* in appearance (see Fig. 1, *A–F*). This parasite is unicellular; the cells are cylindrical and project beyond the common envelope of the *Eudorina*;

* The classification followed is that of West and Fritsch in British Freshwater Algae, etc., Cambridge, 1927. Previous records are, in general, given only where the Alga has been definitely recorded as occurring in the plankton. Many of the species enumerated have also been recorded from the Cape Province and Natal, though not specifically as plankton.

the ends are frequently abstricted. This fungus has been identified by Mr. J. Ramsbottom of the British Museum (Natural History), who was kind enough to examine the material, as *Rhizophidium appendiculatum* (Zopf) Fischer (=*Rhizidium appendiculatum* Zopf).

Eudorina elegans has been recorded from the Nyasa District, Victoria Nyanza, and the Transvaal.

Genus PLEODORINA Shaw.

Pleodorina californica Shaw *forma*; Smith, G. M., Phytoplankton of the Inland Lakes of Wisconsin, 1920, p. 97, Pl. 17.

Sample 25 (May).

Diameter of coenobia from 200 to 230 μ. In the type at least half the cells become gonidial; here the proportion is rather less than a half.

Not previously recorded for South Africa.

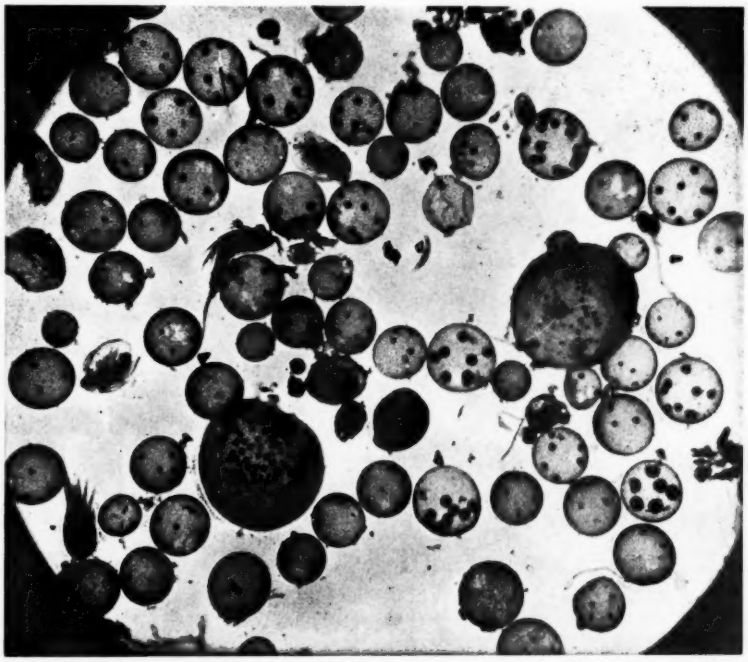


FIG. 2.—Photomicrograph of two species of *Volvox* from Eliazer Pan. Photo by G. E. Hutchinson.

Genus CARTERIA Diesing.

Carteria sp.

Sample 31.

Genus VOLVOX (Linnaeus) Ehrenberg.

Volvox aureus Ehrenb.

Sample 12 (very common), associated with a larger species (see below) which was not so common (Fig. 2).

Volvox spp.—These form the subject of a separate paper (now in preparation) by the present writer and Miss M. A. Pocock.

Samples 6, 12, 18, 22, and 25.

The *Volvox* present in Eliazer Pan resembled *Volvox Rousseletii* West, except that its dimensions were less. No oospores were found in the specimens from the other four samples, but it is probably the same form in all cases.

The *Volvox* in Rietfontein appeared after three years' drought, which shows how well the oospores can withstand desiccation.

SERIES. TETRASPORALES.

Genus SPHAEROCYSTIS Chodat.

Sphaerocystis Schroeteri Chodat.
Samples 13 (rather rare), 19 (common).
Recorded from the Transvaal.

Genus ASTEROCOCCUS Scherffel.

Asterococcus superbus (Cienk.) Scherffel.
Sample 25 (July), not common.
As the structure of the protoplast could not well be made out in the preserved material this determination is rather doubtful.

GROUP. CHLOROCOCCALES.

SERIES. ZOOSPORINAE.

Genus PEDIASTRUM Meyen.

Pediastrum Boryanum (Turp.) Menegh.
Samples 4, 6, 24, 29, 30, 31, 34, 35.
Recorded from Nyasa, Albert Nyanza, Tanganyika, and the Transvaal.
Var. *longicorne* Reinsch; Smith, G. M., Ecology of the Plankton Algae in the Palisades Interstate Park, 1924, Pl. 12, fig. 8.
Sample 31.

Pediastrum duplex Meyen.
Samples 1, 13 (July).
Recorded from Albert and Victoria Nyanza.
Var. *asperum* A. Br.
Samples 11, 17, 25, 38.
Var. *clathratum* A. Br.; West, W. and G. S., Trans. Linn. Soc. Lond., 1895, v, fig. 42.
Sample 13 (July).
Recorded from Nyasa, Victoria Nyanza, and the Transvaal.
Var. *reticulatum* Lagerh.
Samples 6 (January, November), 21, 24.
This variety is said to consist of from 8–16 cells, but in the Potchefstroom Dam one colony was found with 32 cells (Fig. 3, *F*).
Recorded from Victoria and Albert Nyanza, the Cape, and Transvaal.

Pediastrum integrum Näg.
Sample 29.
Recorded from Tanganyika.

Pediastrum simplex Meyen var. *duodenarium* (Bailey) Rabenh. (=*Pediastrum simplex* var. *clathratum* (Schroeter) G. S. West); Smith, G. M., *op. cit.*, Wisconsin Phytoplankton, 1920, Pl. 45, figs. 3, 4, and 6.
Samples 4, 14, 21.
Recorded from Nyasa, Victoria Nyanza, and Transvaal.

Pediastrum tetras (Ehrenb.) Ralfs.
Sample 13 (December).
Recorded from Nyasa, Tanganyika, and Victoria Nyanza.

Genus HYDRODICTYON Roth.

Hydrodictyon reticulatum (L.) Lagerh.; G. M. Smith, *op. cit.*, 1920, Pl. 44, fig. 6.
Sample 22 (rare).

SERIES. AUTOSPORINAE.

Genus TROCHISCIA Kützing.

Trochiscia reticularis (Reinsch) Hansg.
Samples 25, 38 (both very rare).

Genus MICRACTINIUM Fresenius.

Micractinium pusillum Fresen.
Samples 6, 30.
Cells 9–10 μ in diameter; bristles about 22 μ long; cells adhering in groups of 4 and 8.

Genus OOCYSTIS Naegeli.

Oocystis Borgei Snow (Fig. nostr. 3, *A–E*).
Samples 21, 31 (common).

Cells very variable in shape, though fairly constant in dimensions; usually two together in an envelope devoid of thickenings—one cell lying in a plane at right angles to the other. Four-celled colonies, however, are not uncommon. Four chloroplasts in a cell, each containing one pyrenoid.

Length of cell 11–12 μ; width about 7 μ.

Oocystis elliptica, W. West.

Sample 25.

Cells, four together, without polar thickening; common envelope showing thickening. Cells, 21-22 μ long, 10–11 μ broad.

The *forma minor* has been recorded from Nyasa.

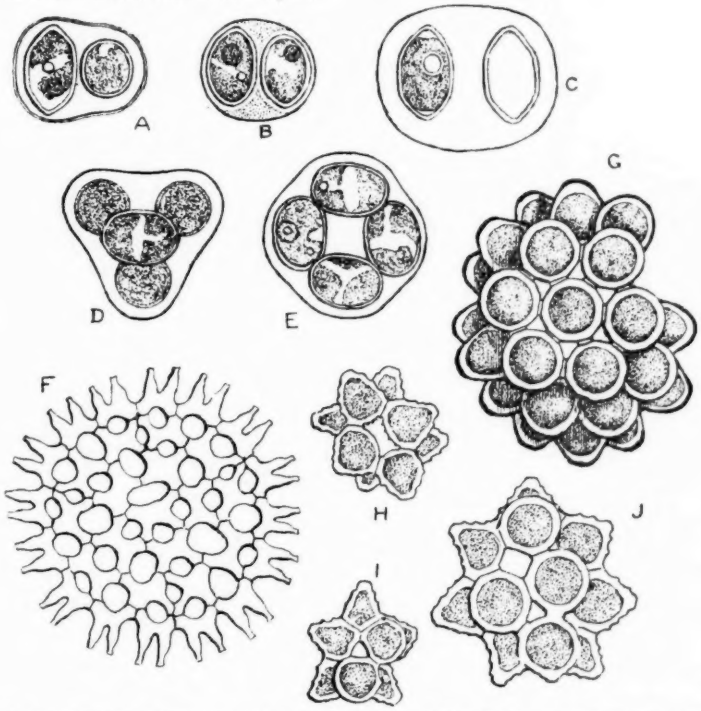


FIG. 3.—*A–E*, *Oocystis Borgei* Snow (×1000). *F*, *Pediastrum duplex* Meyen var. *reticulatum* Lagerh. (×680). *G*, *Coelastrum cambricum* Arch. var. *intermedium* G. S. West (×800). *H–J*, var. *rugosum* var. nov. (×950).

Oocystis natans (Lemm.) Wille.

Samples 6 (rather common), 21 (rare).

Oocystis rupestris Kirchner *forma*.

Sample 31 (rather common), associated with *O. Borgei*.

Forma differt a typo cellulis minoribus, chromatophoris lobatus cum pyrenoide singulo. Long., 5-9 μ; lat., 3–5 μ.

Oocystis sp.

Sample 13.

A form with lateral as well as polar thickening to the cells, but the material was too scanty to render a full description feasible.

Genus NEPHROCYTIUM Naegeli.

Nephrocytium lunatum West.

Sample 25 (very rare).

Genus TETRAËDRON Kützing.

Tetraëdron lobatum (Naeg.) Hansg.; Brunnthaler, Süsswasserflora Deutschlands, etc., Heft 5, 1915, p. 156, fig. 193.

Sample 25 (rare).

Tetraëdron minimum (A. Br.) Hansg. ; G. M. Smith, *op. cit.*, 1920, Pl. 24, fig. 13.
Sample 31 (very rare).
Each angle has a single, short, blunt spine.
Recorded from Tanganyika, Albert and Victoria Nyanza.

Tetraëdron regulare Kütz. var. *torsum* (Turner) Brunnthaler.
Samples 6 (rare), 25 (very rare).
Various forms recorded from Albert Nyanza.

Genus ANKISTRODESMUS Corda.

Ankistrodesmus falcatus (Corda) Ralfs (=*Raphidium falcatus* Corda).
Samples 13, 25.
Recorded from Nyasa and Victoria Nyanza.

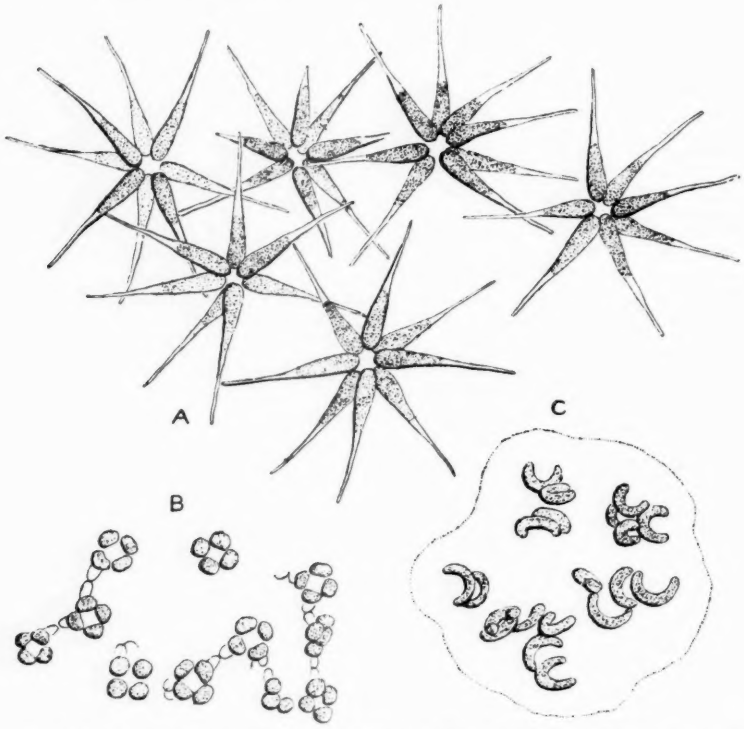


FIG. 4.—*A*, *Actinastrum Schroeteri* G. Huber (×650). *B*, *Westella botryoides* de Wildeman (×370). *C*, *Kirchneriella contorta* Bohlin var. nov. (×650).

Genus ACTINASTRUM Lagerh.

Actinastrum Schroeteri G. Huber (Fig. nostr. 4, *A*).
Sample 6 (November, rather common).
This differs from all other species of *Actinastrum* in the long drawn-out ends of its cells. Huber-Pestalozzi found it in Caledon Pond (Cape Colony) in September 1926, but before his description appeared I had observed it in the Brakpan (Transvaal), and, in a short semi-popular paper contributed to the S.A. Journal of Natural History,* had described it as a variety of *Actinastrum Hantzschii* Lagerh. I did not find either of his varieties.

* Vol. vi, No. 5, pp. 369–76, November 1930.

Genus SELENASTRUM Reinsch.

Selenastrum Bibraianum Reinsch; G. M. Smith, *op. cit.*, 1920, Pl. 31, fig. 7.
Sample 25.

Genus KIRCHNERIELLA Schmidle.

Kirchneriella contorta (Schmidle) Bohlin var. nov. *lunaris* (Fig. 4, *C*). Cellulis 3–4 μ (raro 2 μ) latis, semilunaribus, apicibus rotundatis, vix angustatis, inter se 6–7 μ distantibus, saepe non in eadem planitie; familiis 4 cellularibus, pluribus in involucro gelatinoso irregulariter globoso aggregatis.
Sample 6 (November, rather rare).
The crescentic cells, scarcely narrowed, with rounded apices and a large open space between the apices, resemble *K. obesa* var. *major*, but the cells are not so much curved as in this variety. The two ends often lie in different planes as in *K. contorta* (Schmidle) Bohlin (=*K. obesa* var. *contorta* Schmidle), but the latter has fewer cells of a narrower width. Huber-Pestalozzi records *K. contorta* from Marseilles (O.F.S.) and figures it (*op. cit.*, Abb. 4, fig. 9), but he gives no measurements or description.
The type recorded from Victoria Nyanza and the Orange River Free State.

Kirchneriella obesa (W. West) Schmidle var. *aperta* (Teiling) Brunnthaler.
Sample 13 (January, rare; April and May, rather common).
The type recorded from Albert and Victoria Nyanza.

Kirchneriella sp.
Sample 31 (very rare).
Resembles *K. obesa* var. *major* (Bernard) G. M. Smith, but very few individuals seen.

Genus DICTYOSPHAERIUM Naeg.

Dictyosphaerium Ehrenbergianum Naeg.; G. M. Smith, *op. cit.*, Pl. 20, fig. 12.
Sample 13 (August, November, January).

Dictyosphaerium pulchellum Wood.
Samples 13 (December, January), 6 (November).
Recorded from Nyasa, Victoria Nyanza, Tanganyika, and the Cape (G. Huber).

Genus WESTELLA De Wildeman.

Westella botryoides (W. West) de Wildeman (Fig. nostr. 4, *B*).
Sample 19.
Cells rather flattened on their inner sides, 6–8 μ in diameter.

Genus DIMORPHOCOCCUS A. Braun.

Dimorphococcus lunatus A. Br.; G. M. Smith, *op. cit.*, 1920, Pl. 21, fig. 5.
Sample 38 (very rare).
Recorded from Nyasa and Victoria Nyanza.

Genus CRUCIGENIA Morren.

Crucigenia tetrapedia (Kirchner) W. and G. S. West var. *apiculata* Fritsch and Rich; Trans. Roy. Soc. S. Africa, 1928, xviii, fig. 4, *E–G*.
Samples 13 (September and November), 6 (November).

Genus SCENEDESMUS Meyen.

Scenedesmus acuminatus (Lagerh.) Chodat.
Samples 6 (November), 13 (November), 35.
Recorded from Victoria Nyanza (Woloszynska).

Scenedesmus armatus (Chodat) G. M. Smith var. *major* G. M. Smith.
Samples 9, 25.
Recorded for East Africa and Griqualand West, but not in plankton.

Scenedesmus bijugatus (Turp.) Kütz.
Samples 6, 13 (July).
Recorded from Tanganyika and Victoria Nyanza.
Var. *granulatus* Schmidle.
Sample 6 (November).
Recorded from Nyasa.

Scenedesmus obliquus (Turp.) Kütz.
Sample 6 (November).
Recorded from Nyasa, Albert and Victoria Nyanza.

Scenedesmus opoliensis P. Richter.
Sample 6 (November).
Var. *carinata* Lemm. Also present in the same sample. The type recorded from the Cape.

Scenedesmus protuberans Fritsch and Rich; *op. cit.*, 1928, fig. 6.
Samples 6 (November), 22, 30, 34.
This species is evidently widely distributed in South Africa; it was first described from Griqualand West.

Scenedesmus quadricauda (Turp.) de Bréb.
Samples 9, 21, 25, 31, 34.
Frequently recorded previously.
Var. *bicauda* Hansg.; Printz, Kristianiatraktens Protococcoideen, 1914, Tab. VI, fig. 174.
Sample 21 (very rare).
Var. *parvus* G. M. Smith.
Samples 13 (July, November), 29.

Genus COELASTRUM Naeg.

Coelastrum cambricum Arch. *forma* Bohlin, Die Algen der ersten Regnellschen Expedition, i, 1897, fig. 26.
Sample 38.
Bohlin describes forms transitional to var. *mamillatum* Bohlin and *C. microporum* Naeg. var. *intermedium* (Bohlin) Schmidle, one of which, with rectangular apertures between the cells, is just like that here present.
The type recorded from Albert and Victoria Nyanza.
Var. *intermedium* (Bohlin) G. S. West (Fig. nostr. 3, *G*).
Samples 6 (common, November), 13 (October, January, May).
Cells 14–18 μ in diameter; colonies 54–68 μ in diameter.
Recorded from Nyasa.
Var. *rugosum* var. nov. (Fig. 3, *H–J*).
Cellulis marginibus irregulariter serratis vel rugosis, fenestris inter cellulas triangularibus vel rectangularibus; diam. coenob., 30–40 μ; diam. cell., 10–12 μ.
Sample 6 (rather rare).
Rather small coenobia, with the walls of the cells serrate or rugose.

Coelastrum microporum Naeg.
Sample 13 (September).
Recorded from Nyasa and Victoria Nyanza.

Coelastrum proboscideum Bohlin (=*C. irregulare* Schroeder).
Sample 6 (rare).
Colonies many-celled; up to 80 μ in diameter.

Coelastrum reticulatum (Dangeard) Senn; Brunnthaler, *op. cit.*, Heft 5, fig. 322.
Sample 13 (September).
Recorded from Nyasa, Albert and Victoria Nyanza, and Hartebeest Dam (Transvaal).

GROUP. ULOTRICHALES.

SERIES. EU-ULOTRICHALES.

Genus PEARSONIELLA Fritsch and Rich.

Pearsoniella variabilis Fritsch and Rich; Trans. Roy. Soc. S. Africa, xi, 1924, p. 314, fig. 2.
Sample 22 (occasional filaments).
Recorded from Natal in a film lining the inside of an old wooden water-tub.

Genus HORMIDIUM Kützing.

Hormidium sp.
In Zeekee Vlei (and also in Ronde Vlei) short, very narrow filaments were common. The constituent cells measured in width from less than 2 μ to over 3 μ, and were $1\frac{1}{2}$ to $4\frac{1}{2}$ times as long as broad, very slightly barrel-shaped, and occasionally forming a knee-shaped bend. The terminal cells of the short filaments sometimes showed a curious outgrowth or cap, the nature of which could probably only be determined in fresh material. It recalls *Hormidium pseudostichococcus* Heering.

Genus MICROSPORA Thuret.

Microspora sp. (*pachyderma* (Wille) Lagerh. ?).
Sample 28 (very rare).
Walls of cells 2–3 μ thick.

GROUP. CHAETOPHORALES.

Genus STIGEOCLONIUM Kützing.

Stigeoclonium sp. A fragment only was observed in the sample from Lake Chrissie. This resembled *St. glomeratum* (Hazen) Fritsch *forma* as described for Griqualand West. (Fritsch and Rich, *op. cit.*, 1929, p. 41.)

Genus COLEOCHAETE de Bréb.

Coleochaete orbicularis Pringsh.
Sample 25. Very little seen.
Cells 10–12 μ across.

Genus CHAETOSPHERIDIUM Klebahn.

Chaetospheridium globosum (Nordst.) Klebahn.
Sample 25.

Genus CONOCHAETE Klebahn.

Conochaete sp.
Sample 38 (rare).

GROUP. OEDOGONIALES.

Genus OEDOGONIUM Link.

Oedogonium Pisanum Wittr.
Sample 22, with oospores.

Oedogonium undulatum (Bréb.) A. Br.; Wittr. char. emend. forma δ Hirn.
Sample 25 (May).
Cells 14 μ wide; sterile, but this is one of the species identifiable in the vegetative condition.
Indeterminable species of *Oedogonium* also present in samples 10, 11, 25, 29, 34.

Genus BULBOCHAETE Agardh.

Bulbochaete varians Wittr. var. *Hawaiensis* Nordst.; Hirn, Monogr. u. Iconogr. d. Oedogoniaceen, 1900, Tab. LX, fig. 375.
Sample 25 (May).
Hirn points out that this variety is very near *B. rectangularis* Wittr.
Width of vegetative cell, 15–26 μ; cells 1½ to twice as long. Length of oogonium, 36–70 μ; width, 30–40 μ.
Bulbochaete spp. also present in samples 10, 22, 25, 38.

GROUP. CONJUGATAE.

SERIES. EUCONJUGATAE.

Genus GONATOZYGON De Bary.

Gonatozygon aculeatum Hastings.
Sample 25.
Narrower and shorter than the type, though not markedly so. Width at ends, 10 μ; length, 146 μ.

Genus ZYGNEMA Agardh.

The only filaments of *Zygnema* observed were in sample 6. They were sterile; 27 μ wide.

Genus SPIROGYRA Link.

Spirogyra inflata (Vauch.) Rab.
Sample 25, with zygospores.

Spirogyra longata (Vaucher) Kütz.
Sample 6 (April).
Distinguished by its non-inflated fructifying cells.
Other indeterminable material of *Spirogyra* was present in samples 10, 11, 22, 25.

Genus MOUGEOTIA Agardh.

Sterile, indeterminable material of this genus was found in samples 13 (August, October) and 28.

SERIES. DESMIDIACEAE.

The thick mucilaginous sheaths so characteristic of plankton organisms were very markedly noticeable in many of the Desmids here present. This mucilaginous envelope often followed closely the outline of the cell, including granulations and verrucae.

Genus CLOSTERIUM Nitzsch.

Closterium Archerianum Cleve; W. and G. S. West, Monogr. Brit. Desm., Ray Soc., 1904, i, p. 115, Pl. XI, figs. 8, 9.
Sample 25 (May).
Width, 17–18 μ; distance between apices, 180 μ.

Closterium Dianae Ehrenb. var. *minus* Ducell.
Sample 25.
Dist. inter apic., 200 μ; lat., 20–22 μ.

Closterium Ehrenbergii Menegh.
Sample 22.
Width, 72–90 μ ; distance between apices, 473–550 μ.

Closterium gracile Bréb. ; W. and G. S. West, *op. cit.*, Pl. XXI, figs. 8–10.
Samples 14, 6.
Recorded from Tanganyika.

Closterium Hutchinsonii * sp. nov. (Fig. 5, *D–G*).
C. mediocre, circ. 9 plo long. quam lat., cum cingulo medians, cellulis leviter curvatis, margine ventrali levissime concavo haud tumido, in parte mediana interdum recto, apices versus leviter curvato, apicibus late truncatis angulis

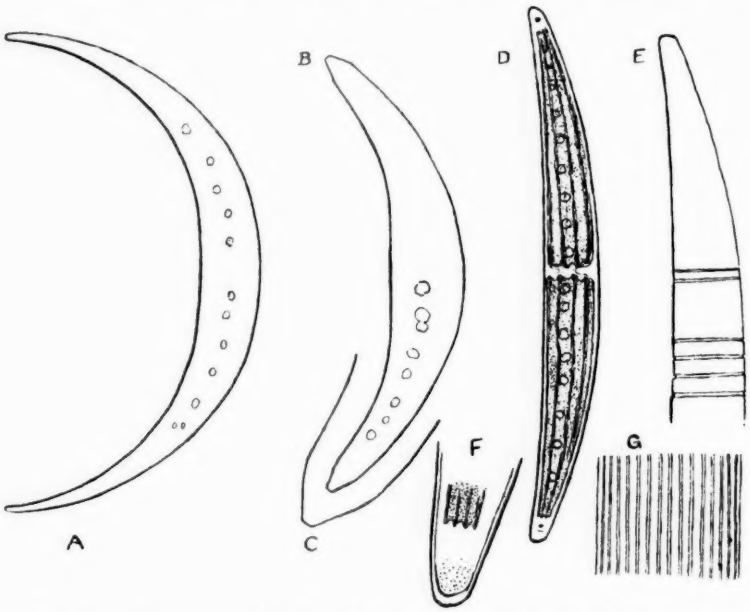


FIG. 5.—*A*, *Closterium prolongum* sp. nov. (× 400). *B*, *C*, *Cl. moniliferum* Ehrenb. var. nov. (*C*, enlarged end ; *B*, × 300.) *D–G*, *Cl. Hutchinsonii* sp. nov. *F*, enlarged end ; *G*, portion of cell-wall showing striae. (*D*, × 340 ; *E*, × 380 ; *F*, *G*, more highly magnified.)

rotundatis ; membrane luteo-fusca, striata, striis saepe indistinctis 10–16 trans cellulam manifestis ; chromatophoris cum ca. 6 costis longitudinalibus praeditis, pyrenoidibus 7–10 in serie axiali vel sparsis. Dist. inter apic., 235–320 μ ; lat. cell., 30–33 μ ; lat. apic., 7–10 μ.
Sample 25 (rather common).
The curvature of the outer margin is from 43° to 53° of arc. The moving granules at the ends of the cells could not be made out at all. The striae on the walls could only be seen in a few individuals. It resembles *Cl. striolatum* Ehrenb., but is distinguished from this species by its straighter inner margin and its narrower apices. It also resembles *Cl. Wittrockianum* Turner, but its apices are more truncate.

Closterium lineatum Ehrenb. ; Grönblad, Finnlandische Desmidiaceen aus Keuru, 1920, Pl. 4.
Samples 22, 25 (May).
Width, 18–22 μ ; length, 580–690 μ.
Specimens with the curious double zygospore characteristic of this species were present in Rietfontein.

Closterium moniliferum (Bory) Ehrenb.
Sample 12, and a pool near.
This species is widely distributed in S. Africa. Recorded in plankton from Nyasa.
Var. *nasutum* var. nov. (Fig. 5, *B*, *C*).

* It is named *Hutchinsonii* after two of the collectors.

C. mediocre, circ. 6–7 plo long. quam lat.; cellulis modice curvatis, margine ventrali leviter inflato, apicibus truncatis triangularibus (*C. nasutum* Wolle a Borge 1918 depictis similibus); membrana laevi, hyalina; chromatophoribus cum pyrenoidibus ca. 7 in serie axiali. Dist. inter apic., 285 μ; lat. cell., 36 μ.

Sample 22.

Borge describes a variety *recurvatum* of this species, which is similar to the present one but has only 4 pyrenoids and is more tumid in the centre. Somewhat similar apices occur in *Cl. Leibleinii* Kütz. var. *podolicum* Gutwinski, but the variety now under consideration is certainly not in the species *Leibleinii*.

Closterium Pritchardianum Arch.

Sample 22.

This species is widely distributed in S. Africa.

Closterium prolongum sp. nov. (Fig. 5, *A*).

Cellulis ca. 8 plo long. quam lat., valde arcuatis, margine ventrali vix tumido, apices versus gradatim attenuatis, apicibus gracillimis rotundatis; membrana laevi, hyalina; chromatophoris cum pyrenoidibus 5–6 in serie axiali. Dist. inter apic., 180–202 μ; lat. cell., 24–25 μ.

Sample 29 (rare).

This differs from other species of ***Closterium*** in its rather long drawn-out slender apices. It resembles *Cl. peracerosum* Gay var. *arcuatus* Fritsch and Rich, described for Griqualand West, but it is much more strongly curved and the apices are more slender. In shape it resembles *Cl. porrectum* Nordst. var. *angustatum* W. and G. S. West, but the cell-wall is not strongly striate. The piece of water in which this ***Closterium*** occurs is slightly brackish and harbours masses of marine Diatoms; the question arises as to whether the contents of this tube had not got mixed with others before leaving South Africa.

Closterium Ralfsii Bréb. var. *hybridum* Rab.

Sample 25 (very rare).

Recorded from Victoria Nyanza.

Closterium Kützingii Bréb.

Sample 25.

Closterium setaceum Ehrenb.; W. and G. S. West, *op. cit.*, i, Pl. XXVI, figs. 9–12.

Samples 25 (July), 32, 38.

In Steenbras Reservoir; length, 280–295 μ; width, 10–11 μ.

Closterium spetzbergense Borge.

Sample 14.

Forma Grönblad; Beitrag zur Kenntniss der Desmidiaceen Schlesiens, 1926, p. 10, figs. 13, 14.

Sample 25 (May).

Closterium stellenboschense Hodgetts; Trans. Roy. Soc. S. Africa, 1925, xiii, p. 74, fig. 8, *A*, *B*.

Sample 32.

The apical granule referred to by Hodgetts was plainly seen; dist. inter apic., 96–120 μ; lat., 12 μ.

Closterium striolatum Ehrenb. var. *sitvense* Gutwinski.

Sample 32.

Long., 220–258 μ; lat., 27 μ.

The type recorded from Nyasa.

Closterium Venus Kütz.

Sample 25.

Dist. inter apic., 52–60 μ; lat., 8–9 μ.

Recorded from Nyasa.

Species of *Closterium* were also present in samples 9, 13, 22, but not in sufficient number to make determination satisfactory.

Genus Pleurotaenium Naeg.

Pleurotaenium Ehrenbergii (Bréb.) de Bary.

Sample 25 (May, July), rare.

The tubercles at the apex were not distinct; long, 400–444 μ; lat. max., 19–24 μ.

Recorded from the Transvaal.

Var. *elongatum* West; *op. cit.*, 1904, i, Pl. XXX, fig. 3.

Sample 32.

Long., 430–556 μ; lat. max., 22 μ.

Pleurotaenium sub-coronulatum (Turner) W. and G. S. West, *formae*.

Sample 22.

Similar to some of the forms of this species found in Natal (Fritsch and Rich, *op. cit.*, 1924, xi, p. 328).

Long., 628 μ; lat. max., 41 μ.

Genus Euastrum Ehrenb.

Euastrum elegans (Bréb.) Kütz. var. *madagascariense* W. and G. S. West, *formae* (Fig. 6, *C*, *D*).

Sample 25 (very rare).

Euastrum spinulosum Delp. subspecies *africanum* Nordst. *forma*.
Sample 25 (not uncommon).
The length agrees rather nearly with that of var. *minus* Nordst., but the breadth is greater than in this variety. Here length and breadth are about equal. Long., 58–80 (plerum 60 μ); lat., 54–70 μ; crass, 32–34 μ; lat. lob. pol., 23 μ; ist., 11–12 μ.
Euastrum spinulosum is an exceptionally variable species; two extreme forms here observed are shown in Fig. 6, *E*, *F*.
Subspecies *inermius* Nordst.; W. and G. S. West, Trans. Linn. Soc. London, 1902, vi, Pl. XIX, fig. 22.
Sample 9 (very rare).
Var. *laticeps* Borge; Die Algen der ersten regnellschen Expedition, 1903, Tab. V, fig. 4.
Sample 38.
Long., 58 μ; lat., 50–52 μ; crass., 26 μ.

Genus MICRASTERIAS Agardh.

Micrasterias Crux-melitensis (Ehrenb.) Hass.; W. B. Turner, The Freshwater Algae (principally Desmidieae) of East India, 1892. Tab. V, fig. 4*a*.
Sample 11.
Individuals were found scarcely differing from Turner's figure of *forma typica*, and agreeing with it in dimensions.
Recorded from Nyasa.
Var. *aequalis* var. nov. (Fig. 6, *A*). Cellulis fere tam longis quam latis, incisionibus inter lobulos laterales inferiores et superiores fere tam profundis quam iis interlobum polarem et lobos laterales, lobulis lateralibus profundiore furcatis quam in typo; membrana delicate punctata. Long., 126–144 μ; lat., 126–144 μ.
Sample 25 (May, July).
In this very rich pan individuals were found larger than the type, and with a deeper incision between the lateral lobes; they recalled *M. radiata* Hass. in these respects, but the long diverging processes of the polar lobe, characteristic of *M. radiata*, were lacking. Bernard (Sur quelques Algues unicellulaires d'eau douce récoltées dans le domaine Malais, 1909, Pl. V, fig. 114) figures a form of *M. Crux-melitensis* which he considers more or less typical, and that, though smaller, is similar to the present form. Turner (*op. cit.*, 1892, Tab. V, fig. 4*b*) figures a form *compressa* with lobulations apparently just as deep as they are here, but all the dimensions he gives are smaller. Joshua (Burmese Desmidieae, 1885, Pl. XXII, figs. 10, 11) depicts a similar form which he refers to a *variety*. All the forms hitherto figured are longer than broad, though often the difference is but slight.
Var. *evoluta* W. B. Turner *forma*.
Samples 22, 25, 38.
The present form has two small teeth at the apex of the polar lobe, but is larger than var. *evoluta*, and the incisions are deeper. In Weltevreden West Pan individuals were seen with the two small teeth at one end and not at the other. This transitional form is figured (Fig. 6, *B*).

Micrasterias denticulata Bréb. var. *angulosa* (Hantzch) W. and G. S. West; *op. cit.*, ii, p. 107, Pl. L, fig. 3.
Sample 32.
The specimens observed differed from this variety only in their smaller dimensions. Long., 178 μ; lat., 140 μ.

Micrasterias Mahabuleshwarensis Hobson; W. B. Turner, *op. cit.*, Tab. VI, fig. 1.
Samples 25 (May), 38.

Micrasterias rotata (Grev.) Ralfs var. *pulchra* Lemm.; Forschungsber. Biol. Stat. Plön, iv, 1896, p. 173, fig. 7.
Sample 32.
Dimensions slightly greater than those given by Lemmermann, but showing the four teeth in the middle of the polar lobe. Long., 306 μ; lat., 265 μ.

Micrasterias tropica Nordst.
Sample 33.
A form with the two processes of the polar lobe inclined upwards, forming angles of about 120° with the apex.
Var. *elongata* Schmidle *forma*.
Sample 25 (July).
This is wider than Schmidle's variety. Long., 110 μ; lat., 70 μ.

Genus COSMARIUM Corda.

Cosmarium binum Nordst.; W. and G. S. West, *op. cit.*, iii, p. 246, Pl. LXXXVIII, fig. 11.
Samples 9, 11, 25.
Recorded from Nyasa, Victoria Nyanza, and Tanganyika.

Cosmarium Blytii Wille, *forma* (Fig. 7, *J*).
Sample 25.
A form intermediate between that of Lütkemüller from Central China (1900) and var. *Novae-Sylvae* W. and G. S. West. The central nodule bears six granules surrounding a central one, as in Lütkemüller's form, but there is only one row of granules round the semi-cell as in var. *Novae Sylvae*.
Long., 20 μ; lat., 17–18 μ; ist., 4–5 μ.
The type recorded from Nyasa, Victoria Nyanza, and Tanganyika.

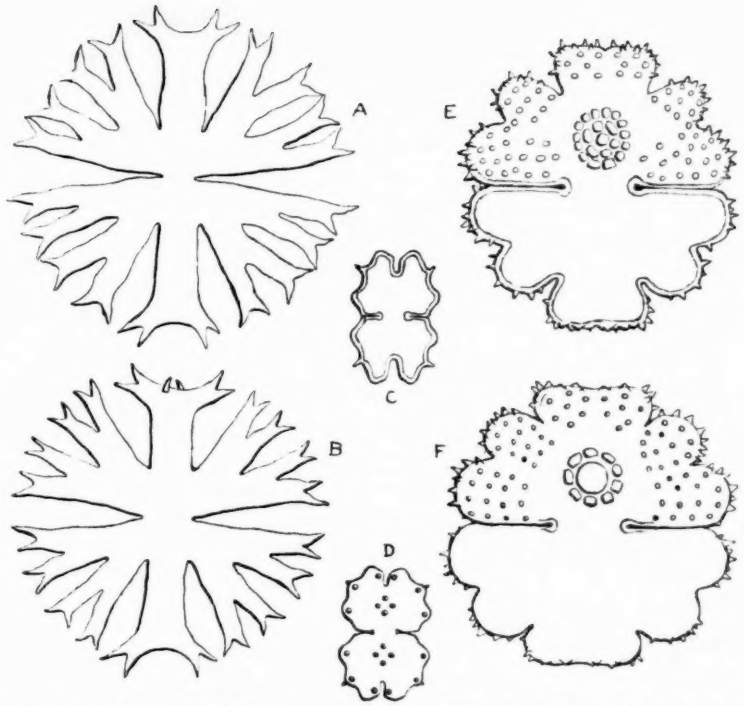


FIG. 6.—*A*, *Micrasterias Crux-melitensis* Hass. var. nov. *aequalis* (×370). *B*, *M. Crux-melitensis* var. *evoluta* Turner, *forma* (×370). *C*, *D*, *Euastrum elegans* Kütz. var. *madagascariense* W. and G. S. West, *formae* (×770). *E*, *F*, *E. spinulosum* Delp. subspecies *africanum* Nordst. *forma* (×670).

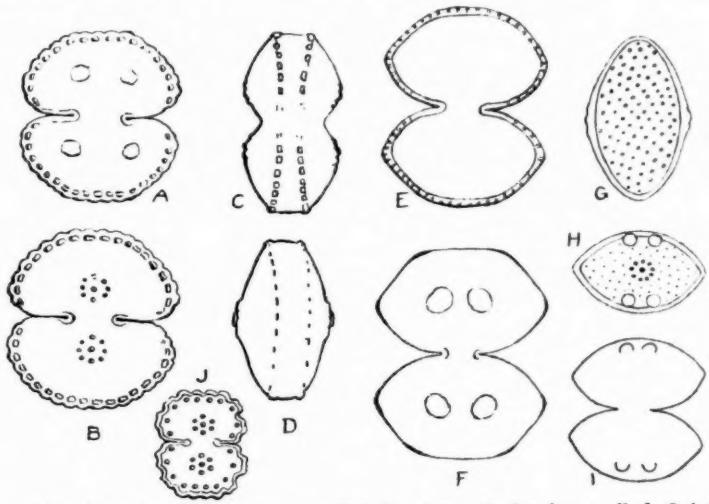


FIG. 7.—*A–D*, *Cosmarium sub-monomazum* sp. nov. *E–G*, *C. sulcatum* Nordst. *forma*. *H*, *I*, *C. heterochondrum* Nordst. *forma*. *J*, *C. Blyttii* Wille, *forma*. *D*, *G*, *H*, end-views; *C*, side-view. (All ×770.)

Cosmarium bioculatum Bréb. var. *hians* W. and G. S. West *forma*.
Sample 13 (July, September, November).
This form differs from var. *hians* in possessing a lateral inflation in end-view. Cell-wall distinctly punctate, apices slightly retuse. Very few individuals seen.
Long., 11–12 μ; lat., 12–13 μ.
The type recorded from Nyasa.

Cosmarium capitulum Roy. et Biss.; W. and G. S. West, *op. cit.*, iii, p. 149, Pl. LXXI, fig. 18.
Sample 25 (common).
The thickness here (12 μ) is a little greater than in the type, but the other dimensions agree.

Cosmarium contractum Kirchn. *forma Jacobsenii* (Roy.) W. and G. S. West; *op. cit.*, ii, Pl. LXI, fig. 26.
Sample 25.
Long., 32–34 μ; lat., 20 μ; ist., 4-6 μ; crass., 16 μ.
Recorded from Nyasa.
Var. *ellipsoideum* (Elfv.) W. and G. S. West *forma*; W. and G. S. West, *op. cit.*, ii, p. 172, Pl. LXI, fig. 31.
Samples 11, 25.
Rather a small form; long., 24–25 μ; lat., 21 μ; ist., 5 μ; crass., 13–14 μ.
This variety recorded from Victoria Nyanza.

Cosmarium Cucurbita Bréb. *forma minor* W. and G. S. West.
Sample 25.

? *Cosmarium heterochondrum* Nordst. *forma* (Fig. 7, *H. I*).
Sample 25 (rare).
Not enough seen to render a satisfactory diagnosis possible. Long., 32–36 μ; lat., 25–30 μ; ist., 6–7 μ; crass. 16–18 μ. Attention should be drawn to the markings seen on the end-view.

Cosmarium Füllebornei Schmidle; *op. cit.*, 1902, p. 67, Tab. I, fig. 19.
Sample 25.
Smaller than that found by Schmidle, but resembling it in general form, in side-view, and in the Pleurotaeniopsis type of chloroplast.
Long., 45 μ; lat., 38–39 μ; ist., 21 μ; crass., 32–33 μ.
Recorded from Nyasa.

Cosmarium granatum Bréb. var. *africanum* Fritsch; Trans. Roy. Soc. S. Africa, ix, 1921, p. 32, fig. 11, *C*.
Samples 29, 31.
This agrees exactly with Fritsch's variety occurring in the Transkei Territories, Cape Colony.
A form of *C. granatum* is recorded in the plankton from Nyasa.

Cosmarium Hammeri Reinsch var. *africanum* Fritsch; *op. cit.*, ix, p. 30, fig. 11, *B*.
Sample 25 (rare).

Cosmarium humile (Gay) Nordst. var. *striatum* (Boldt) Schmidle.
Sample 25 (rare).

Cosmarium laeve Rabenh.
Sample 25.
Recorded from Nyasa and Victoria Nyanza.

Cosmarium Mansangense W. and G. S. West; Ann. Roy. Bot. Gard., Calcutta, vi, 1907, p. 209.
Sample 25 (very rare).
Long., 70–72 μ; lat., 27–28 μ.
This species closely resembles *C. elegantissimum* Lund. var. *simplicius* W. and G. S. West. It appears to differ from the latter in its larger number of granules and its more deeply constricted cells.

Cosmarium margaritatum (Lund.) Roy et Biss. *forma sub-rotundata* W. and G. S. West; *op. cit.*, iv, p. 19.
Sample 22 (very rare).
The type recorded from Tanganyika and Nyasa.

Cosmarium pseudobroomei Wolle var. *convexum* W. and G. S. West.
Samples 9, 25.
Long., 40–44 μ; lat., 40 μ; ist., 13 μ.
The type recorded from Tanganyika and Nyasa.

Cosmarium pseudo-pyramidatum Lund.
Sample 25.
Recorded from Victoria Nyanza and Tanganyika.

Cosmarium punctulatum Bréb. var. *sub-punctulatum* (Nordst.) Börges. *forma*.
Sample 25.
The dimensions are a little smaller than those typical of this variety, agreeing more nearly with those found by Fritsch in specimens from the Cape Peninsula (1917), and with a space free from granules in the middle of the end-view. Long., 28 μ; lat., 23–24 μ; ist., 7 μ; crass., 16 μ.
Forms of this variety are recorded by Huber-Pestalozzi from Marseilles, O.F.S.

Cosmarium pygmaeum Arch.
Sample 25 (rather common).
The semi-cells had the more angular form of some of the published figures, *e.g.* Bernard, *op. cit.*, 1909, Pl. IV, fig. 92.
This was one of the few species in this collection of which the zygospores were present ; the latter were large in proportion, measuring from 16–19 μ in diameter.
Long. cell., 12–15 μ ; lat., 10–11 μ ; ist., 3–4 μ ; crass., 6–7 μ.

Cosmarium pyramidatum Bréb. *forma.*
Sample 25 (very rare).
Smaller than *forma tropica* W. and G. S. West, but resembling it in its slightly inflated semi-cells, and apices less truncate than in the type.
Long., 100 μ ; lat., 67 μ ; ist., 20 μ.
The type recorded from Orange Free State (Huber-Pestalozzi).

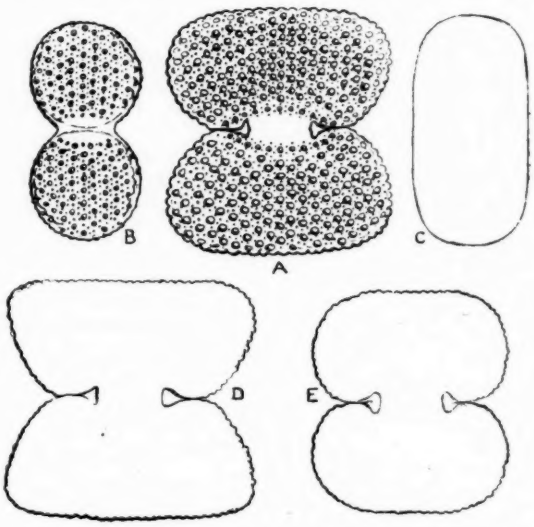


FIG. 8.—*A*, *B*, *C*, *Cosmarium quadrum* Lund. var. *sublatum* (Nordst.) W. and G. S. West. *B*, side-view. *C*, end-view. *D*, *E*, *formae*. (All × 370.)

Cosmarium quadrum Lund. var. *distentum* Fritsch and Rich ; Trans. Roy. Soc. S. Africa, 1929, xviii, fig. 18.
Sample 9 (rare).
Precisely similar to the variety found in Griqualand West.
The type recorded from Tanganyika.
Var. *sublatum* (Nordst.) W. and G. S. West (=*C. sublatum* Nordstedt ; Freshwater Algae collected by Dr. S. Berggren in New Zealand and Australia, 1888, p. 45, Tab. V, figs. 1–51). (Fig. nostr. 8.)
Sample 25 (rare).
It will be seen from Fig. 8 how very closely the forms here observed resemble those figured by Nordstedt for New Zealand. The dimensions also agree closely with those given by him. The granules of the lowest row in the semi-cell are smaller than the others. In vertical view the sides are parallel. Variations in the shape of the semi-cell are illustrated (see Fig. 8, *A*, *D*, *E*).
Long., 82–100 μ ; lat., 71–96 μ ; ist., 25–30 μ ; crass, 48 μ.

Cosmarium Quasillus Lund. *forma.*
Sample 22 (rare).
Smaller than the type. Long., 50 μ ; lat., 47 μ ; ist., 12 μ.

Cosmarium scrobiculatum Fritsch and Rich ; *op. cit.*, 1929, xviii, pt. 1, p. 63.
Sample 25 (rare.)

Cosmarium speciosum Lund. *forma.*
Sample 38.

Only one individual was seen; this had the same number of crenations round the margin as var. *australianum* Nordst., but the dimensions did not agree with this variety.

Long., 78 μ; lat., 34 μ; ist. ca., 14 μ.

*Cosmarium Stephensii** sp. nov. (Fig. 9, *B–D*).

C. magnum, ca. $\frac{1}{3}$ plo long quam lat., profunde constrictum, sinu plerumque angusto-lineari, leviter ampliato; semicellulis a fronte visis subhexagono-ellipticis, *C. achondroides* similibus, in media parte latioribus, angulis basalibus et apicalibus rotundatis, margine levi, membrana scrobiculata, infra apicem cum tuberculis rotundatis paucis; a vertice visis semicellulis late ellipticis, a latere visis sub-circularibus; pyrenoidibus duobus in quaque semicellula.

Sample 25.

Long., 58–63 μ; lat., 47–53 μ; ist., 14–17 μ; crass., 34–36 μ.

This species resembles *C. achondroides* G. S. West, but has only two pyrenoids per semi-cell, and possesses tubercles which recall those of *C. Bewsii* Fritsch and Rich (it differs, however, from the latter species in many respects).

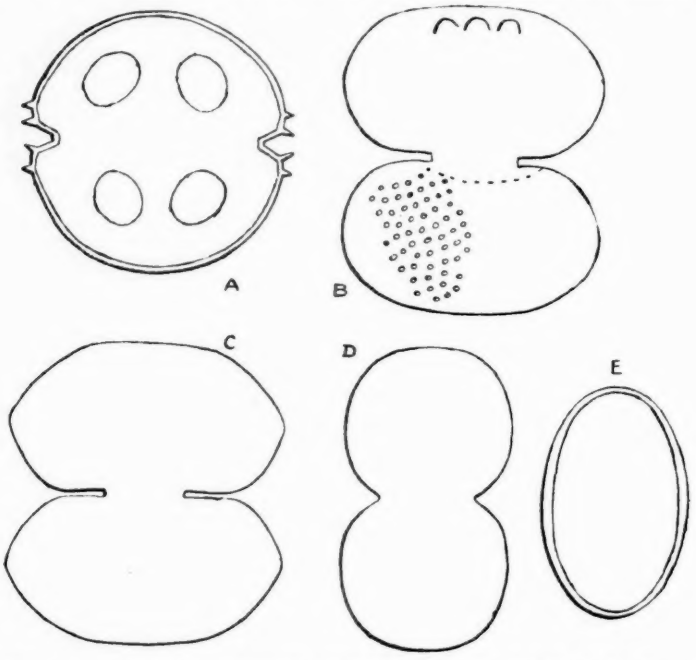


FIG. 9.—*A*, *Cosmarium sub-auriculatum* W. and G. S. West *forma*? *B–E*, *C. Stephensii* sp. nov. *D*, side-view. *E*, end-view. (All × 770.)

? *Cosmarium sub-auriculatum* W. and G. S. West *forma* (Fig. 9, *A*).

Sample 38 (isolated).

Length and breadth almost equal, about 50 μ. It approximates to the form described by Schmidle (*op. cit.*, 1902, Tab. I, fig. 24).

The type recorded from Nyasa and Victoria Nyanza.

Cosmarium sub-monomazum sp. nov. (Fig. 7, *A–D*).

C. subparvum, paene tam latum quam longum, profunde constrictum, sinu angusto-lineari; semicellulis a fronte visis truncato-pyramidatis, angulis basalibus rotundatis, apice leviter deplanato, marginibus ubique undulatis, undulationibus ca. 20 in ambitu semicellulae cum verruca deplanata interdum emarginata intra undulationem unamquamque; semicellulis supra isthmum cum tumore inconspicuo granulo singulo centrali et granulis 8 peripherici munito praeditis. A latere visis semicellulis obovatis, apice leviter deplanato, cum seriebus verrucarum duabus e basi ad apicem divergentibus. A vertice visis semicellulis elongato-hexagonalibus granulo magno centrali utrobique, sinebus duabus verrucarum inter polos praeditis.

* Named after Miss E. L. Stephens.

Long., 34–40 μ; lat., 31–39 μ; ist., 8–10 μ; crass., 18–20 μ.
Sample 25 (rather common).

The individuals observed were mostly so closely covered with mucilage that it was difficult to ascertain the exact nature of the granulations and ornamentation. This species differs from *Cosmarium monomazum* Lund. mainly in the nature of its central granule; it also differs in the more pyramidate shape of the semi-cells.

Cosmarium sulcatum Nordst. (Fig. nostr. 7, *E–G*).
Sample 25.

Although the majority of individuals measured agreed with the dimensions given by W. and G. S. West ("The Freshwater Algae of Madagascar," Trans. Linn. Soc. London, 1895, v, p. 57), some were found a little larger. Long., 36–44 μ; lat., 30–36 μ; ist., 8–10 μ; crass., 21 μ. The angles of the semi-cells often appeared to be slightly thickened; the walls were scrobiculate. (The side-view was not observed.) This species resembles certain forms of *Cosmarium pseudoprotuberans* Kirchn.; it has, however, two pyrenoids in each semi-cell.

Cosmarium taxichondrum Lund. var. *subundatum* Boldt.
Sample (52 rare).
Long., 24–32 μ; lat., 25–26 μ; ist., 6–7 μ; crass., 16 μ.

Genus Xanthidium Ehrenberg.

Xanthidium concinnum Arch. *forma.*
Sample 25.

Only a very few specimens of this small *Xanthidium* were observed. The spines were longer than in the type. Long., 9 μ; lat. sine sp., 10 μ.

Genus Arthrodesmus Ehrenberg.

Arthrodesmus convergens Ehrenb.
Sample 25.
Recorded from Nyasa district.

Arthrodesmus subulatus Kütz. *forma* Lemmermann, Brandenburgische Algen V, 1914, Algologische Beiträge, xii, xiii, fig. 15.
Sample 25 (rare).
Long, slightly divergent spines.
Var. *subaequalis* G. S. West.
Sample 25 (rare).

Genus Staurastrum Meyen.

Staurastrum dilatatum Ehrenb.; Nordstedt, *op. cit.*, 1888, Tab. IV, fig. 18, *a–c.*
Sample 25 (very rare).

Staurastrum brevispinum Bréb.; W. and G. S. West, *op. cit.*, 1912, Pl. CXXIII, fig. 1.
Sample 25 (rare).
Long., 29 μ; lat., 26 μ; ist., 9–10 μ.
A variety recorded from Victoria Nyanza.

Staurastrum Clepsydra Nordst. var. *obtusum* Nordst. *forma*, Borge, Die von Dr. A. Löfgren in São Paulo gesammelten Süsswasseralgen, 1918, Tab. IV, fig. 11. (Fig. nostr. 10, *A–D.*)
Sample 25 (common).
The dorsal margin is almost straight, and the cell-wall only slightly thickened at the angles.
Long., 25–32 μ; lat., 23–30 μ; ist., 5–6 μ.
An abnormal individual is shown in Fig. 10, *B.*

Staurastrum cupsidatum Bréb.; West and Carter, British Desmidiaceae, 1923, v, Pl. CXXXII, fig. 14.
Sample 25.
Recorded from Victoria Nyanza.

Staurastrum dejectum Bréb. var. *patens* Nordst. *forma*; Nygaard, 1931, fig. 44.
Sample 13 (January, very rare).
The spines are divergent.

Staurastrum Dickei Ralfs var. *maximum* W. and G. S. West *forma* (Fig. nostr. 10, *E, F*).
Sample 25 (rather rare).

The size is intermediate between that found by the Wests for var. *maximum* in Madagascar and the same variety in North America, and the cell-wall is more closely punctate than in the Madagascar form. The spines are rather long (about 9 μ) and convergent; the tips not recurved.
Long., 50–60 μ; lat. sine spin., 56–60 μ; ist., 11–13 μ.

Staurastrum fissum W. B. Turn. *forma* (Fig. 13, *C*).
Sample 25.

These individuals differed from the type only in their divergent processes; in Turner's figures the processes are horizontal. (The Freshwater Algae of East India, 1892, fig. 24, *a, b.*)

The figure (13, *C*) has been placed close to that of *St. tohopekaligense* to show the resemblance between the two in the shape of the semi-cells.

Staurastrum Füllebornei Schmidle (Fig. nostr. 11, *F, G*).
Sample 25 (very rare).

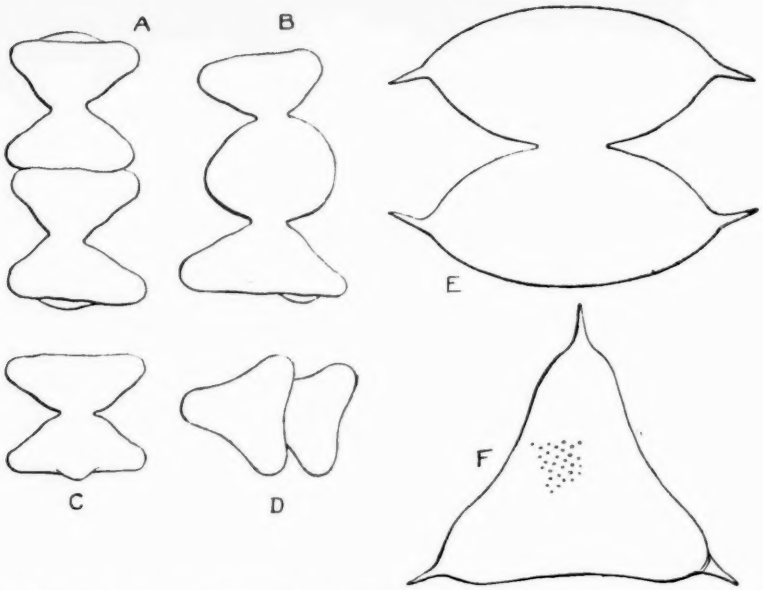


FIG. 10.—*A–D, Staurastrum Clepsydra* Nordst. var. *obtusum* Nordst. *forma*. *B*, abnormal individual. *E, F, St. Dickei* Ralfs var. *maximum* W. and G. S. West. *forma*. *D, F*, end-views. (All × 770.)

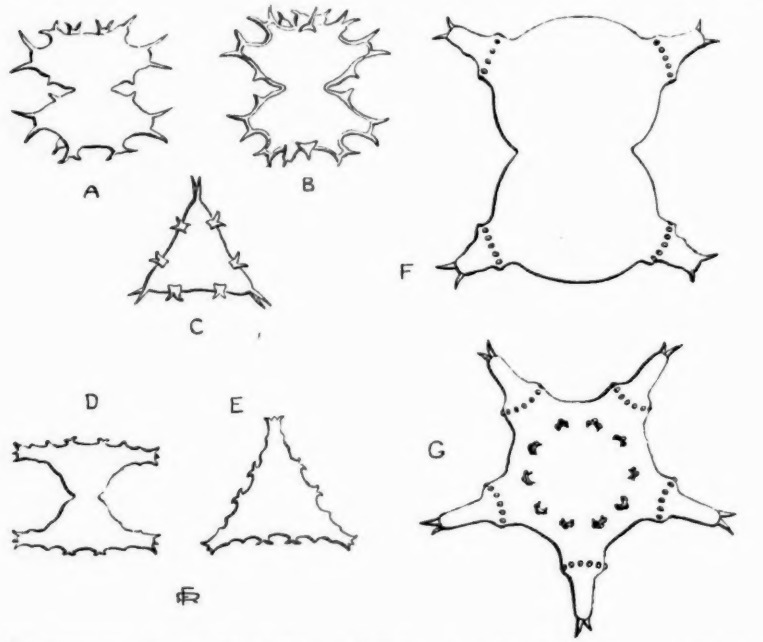


FIG. 11.—*A–C, Staurastrum furcatum* Ehrenb. *forma*. *D, E, St. polymorphum* Bréb. var. *munitum* W. West, *forma minor* Fritsch and Rich. *F, G, St. Füllebornei* Schmidle. *C, E, G*, end-views. (All × 770.)

This handsome *Staurastrum* is evidently the same as that described by Schmidle from Nyasa, though differing slightly from his figures (*op. cit.*, Tab. II, figs. 10, 10*a*). There are twice as many verrucae in the apical circle as there are arms. I did not notice the small processes above the isthmus, but then only two or three individuals were seen.

Long., 48 μ; lat. cum proc., 50 μ; lat. sine proc., 30 μ; ist., circa 20 μ.

Recorded from Nyasa.

Staurastrum furcatum Ehrenb.

Sample 25 (rare).

Forma (Fig. 11, *A–C*). In addition to the type, individuals were present in the same sample possessing a simple spine on the ventral margin of the semi-cell just below the lateral process.

Long. sine proc., 22–28 μ; lat. cum. proc., 26–39 μ; sine proc., 18–20 μ; ist., 8–10 μ.

Staurastrum leptocladum Nordst. var. *cornutum* Wille (Fig. nostr. 13, *F*).

Samples 25 (May), 38.

G. M. Smith (*op. cit.*, 1924, p. 103) gives reasons, based on his experience with the Alga in Ontario, New York, and Wisconsin, for including this variety in the type. Grönblad, however, considers that the two should be separate (Beitrag zur Kenntniss der Desmidiaceen Schlesiens, 1926, p. 29). The processes in the present samples have not the

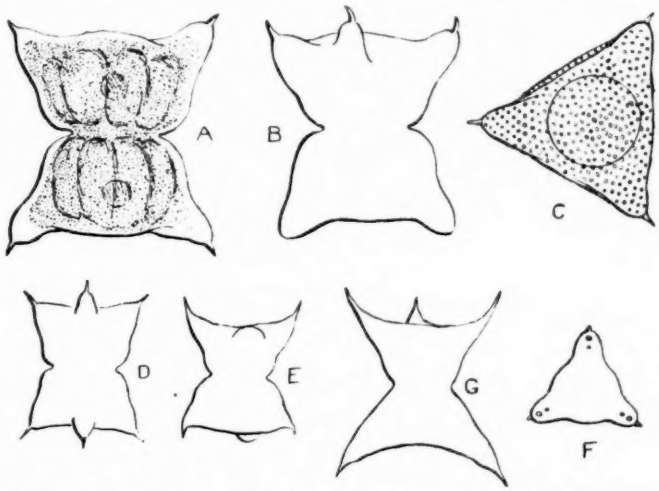


FIG. 12.—*A–C*, *Staurastrum leptodermum* Lund. var. *subcorniculatum* var. nov. *D–F*, var. *Ikapoae* (Schmidle) W. and G. S. West, *forma minor*. *C*, *F*, end-views. (All $\times$770.)

upward and outward inclination depicted in G. M. Smith's figures but are at first almost horizontal, then curved gracefully towards the isthmus, and, finally, slightly upwards at the tips, more like West's figure 1895 (Freshwater Algae of Madagascar; *op. cit.*, Pl. IX, figs. 12 and 13).

Long., 35–38 μ; lat. cum proc., 84–120 μ; ist., 6–8 μ; crass., 10–12 μ.

The type recorded from Nyasa.

Staurastrum leptodermum Lund. var. *Ikapoae* (Schmidle) W. and G. S. West, *forma minor* (Fig. 12, *D–F*).

Sample 25.

Some individuals resembled Lütkemüller's *forma* * *minor* of *St. leptodermum* in shape but were much smaller. The end-view showed the slight bulge in the middle of each side which is present in var. *Ikapoae* and not in the type; I can, therefore, only consider it a form of this variety.

Long., 20–26 μ; lat. cum. spin., 20–30 μ; ist., 10, 11 μ.

Var. *subcorniculatum* var. nov. (Fig. 12, *A–C*). S. mediocre, tam long. quam lat., paullo constrictum, sinu aperto subrectangulari; semicellulis late subcuneatis, e basi lata gradatim dilatatis, lateribus leviter convexis, apice levissime convexo, angulis superioribus divergentibus obtusis, spino brevi munitis. A vertice visis triangularibus, lateribus paene rectis. Membrana aequaliter punctata.

Long. cell. sine protub., 39–44 μ; c. protub., 43–48 μ; lat., 37–44 μ; lat. ist., 18–20 μ; long. spin. ca., 3 μ.

Sample 25 (rather rare).

It is difficult to know whether to refer this variety to *St. leptodermum* or *St. corniculatum* as it shows resemblances

* Lütkemüller, Desmidiaceen aus den Ningpo Mountains in Central China, 1900, figs. 30, 31.

to both. It differs slightly from the figures of any described form or variety of *St. corniculatum* Lund. though agreeing somewhat with the description of var. *spinigerum* West ; it differs from the latter in its punctate walls, its dimensions, and in being more deeply constricted It is very near *St. leptodermum* var. *Ikapoae* (Schmidle) W. and G. S. West, but, again, its walls are punctate and it is more deeply constricted ; its upper angles, further, are more definitely produced. It recalls *St. unguiferum* Turner, but that has the processes directed upwards and inwards instead of outwards as in the present instance. On the whole it seems best to consider it a new variety of *St. leptodermum*.

Staurastrum Manfeldtii Delponte ; Mem. Ac. Torino, 1878, Ser. II, t. 30, Tab. XIII, fig. 10.
Sample 25 (rather rare).
Long., 40–45 μ ; lat. cum proc., 56–90 μ ; ist., 10–11 μ.
This species closely resembles *St. Sebaldi* Reinsch var. *ornatum* Nordst. but has not such a convex apex and is smaller. The individuals here noticed showed the irregularity in the apical verrucae which was originally described for the Italian specimens but, according to West and Carter, was not observable in the British specimens. (*Op. cit.*, 1923. v, p. 115.)

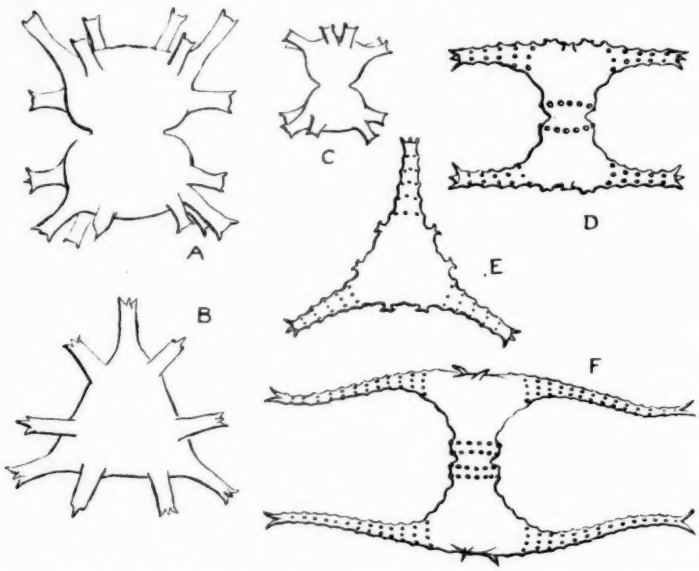


FIG. 13.—*A*, *B*, *Staurastrum tohopekaligense* Wolle var. *trifurcatum* W. and G. S. West, *forma*. *C*, *St. fissum* W. B. Turn., *forma*. *D*, *E*, *St. sub-vestitum* sp. nov. *F*, *St. leptocladum* Nordst. var. *cornutum* Wille. *B*, *E*. end-views. (All × 770.)

Var. *annulatum* W. and G. S. West ; A contrib. to the Freshw. Algae of the N. of Ireland, 1902, fig. 31*a*.
Sample 25.
Long., 42–43 μ ; lat. cum proc., 60–70 μ ; ist. ca., 9 μ.

Staurastrum paradoxum (Meyen) Ralfs ; Nordstedt, *op. cit.*, 1888, figs. 10, 11.
Samples 13, 21.
In the Potchefstroom Dam sample the sides of the individuals in vertical view were slightly convex as in var. *evolutum* W. and G. S. West, but the present form is larger, its dimensions agreeing with those of the type.
Long., 22 μ ; lat. cum proc., 40–42 μ ; ist., 6 μ.
Recorded from Victoria Nyanza.
Also present in this sample are forms closely resembling those of var. *longipes* Nordst. (Borge, Schwedisches Süsswassersplankton, 1900, Bot. Notiser, Tab. 1, fig. 4).

Staurastrum polymorphum Bréb. var. *munitum* W. West *forma minor* Fritsch and Rich (*op. cit.*, xviii, Pt. 1, 1929, fig. 21, *F*, *G*). (Fig. nostr. 11, *D*, *E*.)
Sample 25 (rare).
In these individuals two bifurcate spines just below the apex were noticeable ; they had probably been overlooked in the specimens from Griqualand West where this form was first described.
Long., 22–24 μ ; lat. cum proc., 34 μ ; ist., 4–6 μ.
The type recorded from Nyasa.

Staurastrum Schuurmani * sp. nov. (Fig. 14, *H*, *I*).

Cellulis parvis, profunde constrictis, sinu obtusangulo aperto, isthmo angusto; semicellulis obverse triangularibus, apice leviter convexo, seriebus duabus verrucarum emarginatum intra apicem praeditis, processibus elongatis divergentibus gracilibus granulis transverse dispositis et spinis 2 vel 3 modice elongatis in apicem munitis; corpore semicellulae in ambitu delicate crenulato. A vertice visis anguste ellipticis.

Long. sine proc., 17–21 μ; lat. cum proc., 50–60 μ (plerum, 50 μ); ist., 3–5 μ; crass., 9 μ.

Sample 13 (November, April, May).

This species somewhat resembles *St. caledonense* G. Huber, but the latter has parallel sides when seen in end-view. It differs from *St. multinodulosum* Grönblad for the same reason and appears to have relatively longer arms. It also resembles certain forms of *St. brachioprominens* Boergesen, which, however, has proportionately broader semi-cells and is not so deeply constricted. It is something like *St. Stephensii*, which is present in the same sample, but its semi-cells are more elongated.

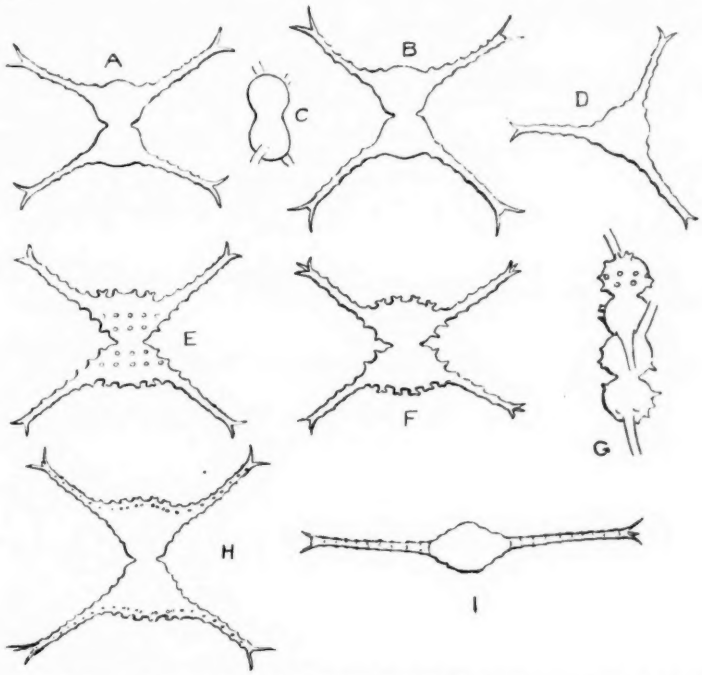


FIG. 14.—*A–D*, *Staurastrum volans* W. and G. S. West. *E–G*, *St. Stephensii* sp. nov. *H*, *I*, *St. Schuurmani* sp. nov. *C*, *G*, side-views; *D*, *I*, end-views. (All ×770.)

Staurastrum Sebaldi Reinsch var. *ornatum* Nordst. *forma* (Fig. 15).

Sample 25 (May and July).

The present form exhibits the tri-spinate verrucae which are recorded for this variety and some of its forms. Groups of granules (from 5 to 8) above the isthmus recall f. *orientalis* W. and G. S. West, but the latter has much shorter arms. The cells were more deeply constricted than is usual, thus making the isthmus smaller. There was a great constancy in the dimensions.

Long., 58–64 μ; lat., 84–100 μ; ist., 11–14 μ.

Var. *ornatum*, as pointed out by West and Carter (*op. cit.*, v, p. 168), is very similar to *St. Manfeldtii* (a species which is also present in this sample). It is certainly difficult to distinguish the two, but the individuals in Weltevreden West Pan formed two distinct groups which I have separated as above.

Staurastrum Stephensii † sp. nov. (Fig. 14, *E–G*).

Cellulis parvis, biradiatus, profunde constrictis, sinu aperto; semicellulis obverse triangularibus, cum 4–5 verrucis

* Named after one of the collectors.

† Named after Miss E. L. Stephens, to whom so much of this collection is due.

emarginatis in apicem praeditis ; processibus sublongis divergentibus, spinis 2 vel 3 in apicem et seriebus 5–6 denticulorum munitis ; supra isthmum cum seriebus transversis granularum 2.

Long. sine proc., 16–18 μ ; lat. cum proc., 37–41 μ ; ist., 4–5 μ.

This species is very like *St. vestitum* Ralfs var. *subanatinum* W. and G. S. West, but it is much smaller, has more divergent processes, and is bi-radiate. In general form it somewhat resembles *St. volans*, which is present in the same Lake, but it is more ornate than the latter. The semi-cells are more compressed than in *St. Schuurmani*, another allied species.

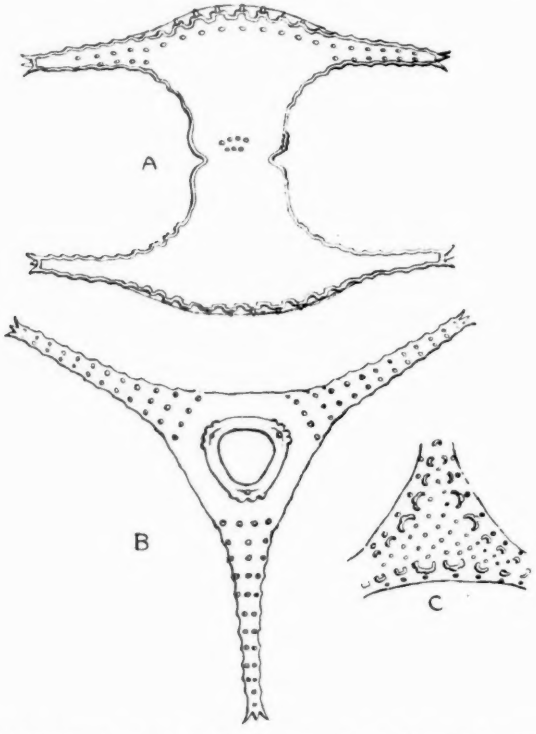


FIG. 15.—*Staurastrum Sebaldi* Reinsch var. *ornatum* Nordst. *forma*. *B*, *C*, end-views ; *B*, ventral ; *C*, dorsal. (×770).

Staurastrum sub-johnsonii sp. nov. (Fig. 16, *A*, *B*).

S. submagnum, fere duplo lat. (proc. incl.) quam long., modice constrictum, sinu aperto acuto vel fere rectangulari, isthmo lato ; semicellulis biradiatis, subcuneatus, superne dilatatis, apice levissime convexo serie verrucarum praedito et intra marginem utrobique cum seriegranularum vel verrucarum, partibus basalibus semicellularum inflatis cum seriebus granularum duabus transversalibus, processibus elongatis leviter convergentibus, spinis 3 vel 2 in apicem praeditis, cum seriebus denticulorum pluribus. A vertice visis semicellulis ellipticis, in media parte leviter deplanatis, processibus denticulatis. Long., 60–65 μ ; lat. cum proc., 120–130 μ ; ist., 15 μ ; crass., 20–21 μ.

Sample 25 (not uncommon).

This differs from *St. Johnsonii* W. and G. S. West in its greater size, slightly different shape, and in the lateral processes being convergent rather than divergent. It recalls the form of *St. Sebaldi* var. *ornatum* present in the same sample, but has longer arms. There are about 15 or 16 denticulations on the arms which are gracefully curved firs downwards, and then slightly upwards at the tips. There is a series of granules just below the apical verrucae.

Var. *minor* var. nov. (Fig. 16, *C*).

Sample 25.

This variety differs from the type in its smaller size, in the cells being usually tri-radiate, and in the number of denticulations in the arms being less (only about 8). The ornamentation is similar to that of the type.

Long., 40–43 μ ; lat. cum proc., 60–70 μ ; ist., 9 μ.

Staurastrum sub-vestitum sp. nov. (Fig. 13, *D*, *E*).

Staurastrum mediocre, ca. 1½ plo. lat. quam long., profunde constrictum, sinu aperto ; semicellulis cyathiformibus, in parte inferiore inflatis, apice paullo convexo cum verrucis emarginatis vel spinis bifurcatis paucis, angulis superioribus gradatim productis, processibus sublongis plerumque fere horizontalibus vel paullo convergentibus, spinis 3 in apicem praeditis, cum seriebus ca. 5 denticulorum. A vertice visis triangularibus, angulis productis, processibus denticulatis, lateribus fere rectis cum spinis 2 bifurcatis munitis. Long., 26–31 μ ; lat. cum proc., 36–50 μ ; ist., 5–7 μ.

Sample 13 (November, January, April).

This shows certain resemblances to *St. vestitum* Ralfs, which is a very variable species, but its general shape is different ; *St. vestitum* has a more flattened or compressed body, the characteristic bifurcate spines are nearer together and the isthmus is wider. There is also a resemblance to some of the smaller forms of *St. anatinum* Cooke and Wills, but from these it is distinguished by its end-view, which possesses two bifurcate spines on each lateral margin.

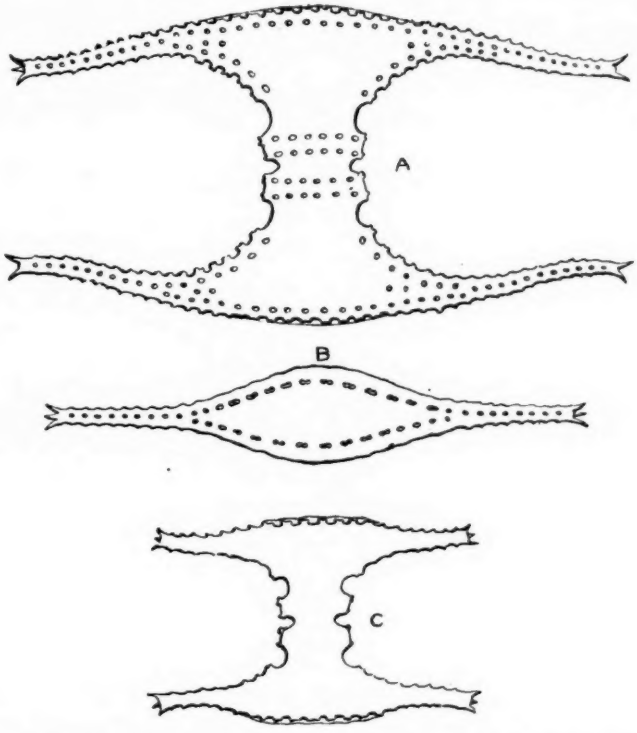


FIG. 16.—*A*, *B*, *Staurastrum sub-johnsonii* sp. nov. *B*, end-view. *C*, var. *minor* var. nov. (All ×770.)

Staurastrum tetracerum Ralfs *forma trigona* Lund. ; West and Carter, *op. cit.*, v, Pl. CXLIX, fig. 4.

Sample 25.

Long. sine proc., 10–12 μ ; lat. cum proc., 22–25 μ ; ist., 4–5 μ.

The type recorded from Tanganyika and the Transvaal (Hartebeestpoort Dam).

Staurastrum tohopekaligense Wolle (=*St. nonanum* W. B. Turner) var. *trifurcatum* W. and G. S. West, *forma* (Fig. 13, *A*, *B*).

Sample 25 (July).

Var. *trifurcatum* is characterised by possessing shorter processes than the type, with bifurcate or trifurcate apices. The form here present shows small spines, similar to those figured by G. M. Smith for his var. *brevispinum*. Long. sine proc., 28–36 μ ; cum proc., 40–49 μ ; lat. sine proc., 24–27 μ ; cum proc., 39–48 μ ; ist., 14–16 μ. On the whole a little smaller than var. *trifurcatum* but with a slightly larger isthmus.

The type recorded from Victoria Nyanza.

Staurastrum vestitum Ralfs.
Sample 25.

Staurastrum volans W. and G. S. West; Freshwater Algae of Madagascar; Trans. Linn. Soc. London, 1895, v, Pl. IX, figs. 10–11. (Fig. nostr. 14, *A–D.*)
Sample 13 (July, December, January, May).
The Wests give 18–19 μ as the length; the individuals in Florida Lake were barely as long (14–17 μ), but they showed the convex apex to the semi-cells characteristic of the species and the slender two-spined processes. This *Staurastrum* is very like *St. grallatorium* Nordst. var. *americanum* W. and G. S. West, which, however, has arms more horizontally directed, with more crenulations on them. In describing this variety * the Wests do not draw attention to the resemblance to *St. volans*. G. M. Smith (*op. cit.*, 1924, p. 100) makes this variety of *St. grallatorium* a separate species, *St. americanum*.
Long., 14–17 μ; lat. cum proc., 32–44 μ; ist., 4–6 μ; crass., 8–9 μ.
Recorded from Victoria Nyanza.
Occasional tri-radiate forms were observed (see fig. 14, *D*).

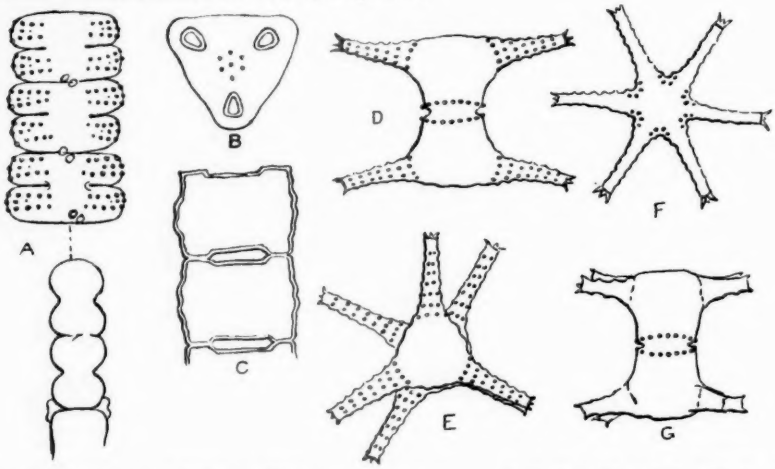


FIG. 17.—*A*, *Sphaerozosma Aubertianum* West var. nov. *compressum*. *B*, *C*, *Desmidium Baileyi* (Ralfs) De Bary var. *coelatum* (Kirchn.) Nordst. *D*, *E*, *F*, *Staurastrum zonatum* var. *productum* W. and G. S. West, *forma*. *G*, *St. zonatum* Boerg. var. *horizontale* Borge *forma*. (All × 770.)

Staurastrum zonatum Börg. var. *horizontale* Borge *forma* (Fig. 17, *G*).
Sample 25 (very rare).
A little smaller than Borge's variety, and the very few individuals observed had only four arms whereas those observed by him had six.
Long., 28–30 μ; lat. cum proc., 34–36 μ; ist., 9–10 μ.
Var. *productum* W. and G. S. West, *forma* (Fig. 17, *D*, *E*, *F*).
Sample 25.
In this form the arms are not quite so long as in var. *productum*. There are regularly seven denticulations along each arm. Three, four, five, and six-rayed individuals were found; at least two were observed in which one semi-cell was three-rayed, the other four-rayed (see Fig. 17, *E*).
Long., 28–32 μ; lat. cum proc., 45–55 μ; ist., 9–12 μ.

Genus COSMOCLADIUM Bréb.

Cosmocladium constrictum Arch.; West and Carter, *op. cit.*, v, Pl. CLVIII, fig. 1.
Sample 25 (rare).
Not previously recorded for S. Africa.

Genus SPHAEROZOSMA Corda.

Sphaerozosma Aubertianum West var. nov. *compressum* (Fig. 17, *A*).
Cellulis evidenter latis quam longis, profunde constrictis, sinu lineari; semicellulis elliptico-oblongis cum seriebus

* "North American Desmidieae," Trans. Linn. Soc. London, 1896, Bot. V, p. 265.

horizontalibus duabus, granularum in media parte semicellulae interruptis, et granulis supernumerariis paucis in marginem lateralem. Long., 13–16 μ; lat., 24–27 μ; ist., 8–10 μ; crass., 10–12 μ.

Sample 25 (rather common).

In front-view this variety closely resembles *Sph. vertebratum* (Bréb.) Ralfs var. *depressum* Grönblad, but as the semi-cells are subspherical in side-view it cannot be placed under *vertebratum*, a species that has an oblong, slightly constricted, lateral view. There is a great resemblance between *Sph. vertebratum* var. *depressum* and *Sph. Aubertianum* West var. *Archeri* West.

Sphaerozosma granulatum Roy et Biss.; West and Carter, *op. cit.*, v, p. 213, Pl. CLX, fig. 7.

Sample 13 (December).

Var. *pergranulatum* W. and G. S. West; Trans. Linn. Soc. London, 1902, v, p. 193, Pl. XXII, fig. 28.

Sample 25 (May, July).

Long., 10–15 μ; lat., 10–11 μ; ist., 4–5 μ.

Genus Onychonema Wallich.

Onychonema filiforme (Ehr.) Roy and Biss.; West and Carter, *op. cit.*, v, Pl. CLX, figs. 13, 14.

Sample 25 (May).

Onychonema laeve Nordst. var. *micracanthum* Nordst.

Sample 25.

The variety recorded from Nyasa.

Genus Hyalotheca Ehrenberg.

Hyalotheca mucosa (Mert.) Ehr.; West and Carter, *op. cit.*, v, Pl. CLXII, fig. 1.

Samples 11, 25 (July).

The examples found in Lake Chrissie are slightly narrower than the type—they are only 14 μ wide.

Recorded from Tanganyika.

Genus Desmidium Agardh.

Desmidium Bailey (Ralfs) De Bary var. *coelatum* (Kirchn.) Nordst.; Bernard, Algues unicellulaires d'eau douce récoltées dans le domaine Malais, 1909, Pl. I, fig. 11. (Fig. nostr. 17, *B*, *C*.)

Samples 9, 13, 25.

The type is described as being destitute of a gelatinous sheath; here, in the specimens from Weltevreden West and Florida Lake, the sheath was distinctly seen. Long., 17–18 μ; lat., 24–25 μ.

CLASS II. HETEROKONTAE.

GROUP. HETEROCHLORIDALES.

Series. Heterocapsales.

Genus Botryococcus Kützing.

Botryococcus Braunii Kütz.

Samples 5, 9, 22, 23, 25, 26, 27, 37.

In Maloti Lake, P.E.A., it is very common, forming brick-red granules (associated with *Microcystis flos-aquae*).

Recorded from Nyasa, Victoria Nyanza, Tanganyika, the Transvaal, and the Cape.

Botryococcus protuberans W. and G. S. West.

Samples 4, 13 (July), 24, 25, 26.

The cells project prominently from the gelatinous membrane in which they are embedded. According to Pascher (Süsswasserflora, Heft 11, p. 92), *B. protuberans* is only a stage in development of *B. Braunii*.

GROUP. HETEROCOCCALES.

Genus Ophiocytium Naegeli.

Ophiocytium cochleare A. Br.

Sample 25 (rare).

Recorded from Nyasa.

CLASS III. CHRYSOPHYCEAE.

GROUP. CHRYSOMONADALES.

Genus Mallomonas Perty.

Mallomonas alpina Pascher et Ruttner; Süsswasserfl., Heft 2, 1913, p. 36, fig. 58*a*.

Sample 13 (September, January).

The length of the cells is a little greater than usual (=26–31 μ).

Genus DINOBRYON Ehrenberg.

Dinobryon divergens Imhof; West and Fritsch, Brit. Freshw. Algae, fig. 137, *A*, under *D. cylindricum* var. *divergens*.
Samples 13 (never common, August, September, October, April, May) and 25 (July).
Length of cells, *circa* 40 μ; greatest width, 10 μ.

CLASS IV. BACILLARIALES.

Since in the majority of cases the amount of material available was not suitable for making special Diatom preparations, I have determined the Diatoms only where they were abundant or showed such striking features that they could be determined without special preparation.

Melosira ambigua (Grun.) Müller.
Sample 13.
Very common in Florida Lake every month except January when it was not so common. Forming auxospores in December and January.

Melosira granulata (Ehrenb.) Ralfs.
Samples 21, 24.
Recorded from Albert Nyanza and the Transvaal.
Var. *angustissima* Müller.
Samples 6, 21, 23, 24.
Seldom with more than 6 cells on end.
Recorded from Nyasa, Victoria Nyanza, the Cape, and the Transvaal.

Cyclotella Meneghiniana Kütz.
Samples 6, 31.
Recorded from Transvaal (Huber).

Chaetoceras sp.
Common in Sample 29.

Tabellaria flocculosa (Roth.) Kütz.
Samples 13, 32.
See Introductory Remarks, p. 153.

Synedra acus Kütz. var. *delicatissima* W. Sm.
Sample 29.
Recorded from the large African lakes (West).

Synedra longissima W. Sm. var. *acicularis* Meister.
Sample 29.

Synedra paludosa Meister.
Sample 29.

Synedra ulna (Nitzsch.) Ehrenb.
Sample 6.
Recorded from Albert Nyanza (West).

Eunotia diodon Ehrenb.
Sample 25.

Eunotia gracilis Ehrenb.
Sample 25.

Eunotia pectinalis Kütz.
Sample 25.

Achnanthes spp.
Samples 5, 13.

Cocconeis sp.
Samples 29, 31.

Anomoeoneis sphaerophora Pfitzer.
Sample 21.

Navicula (*Pinnularia*) *dactylus* Ehrenb.
Samples 25, 38.

Navicula (*Pinnularia*) *madagascarensis* Fritsch.
Sample 38.

Navicula (*Pinnularia*) *nodosa* W. Sm.
Sample 25.

Navicula (*Frustulia*) *rhomboides* Ehrenb.
Sample 32.

Navicula (*Pinnularia*) *stauroptera* Rabenh. var. *interrupta* Cleve.
Sample 25.

Navicula spp.
Samples 25, 29, 38.

Stauroneis anceps Ehrenb.
Sample 25.

Stauroneis Phoenicenteron Ehrenb.
Samples 11, 25.
Recorded from Albert Nyanza.

Gomphonema gracile Ehrenb. var. *lanceolata* Kütz.
Samples 9, 25.
Found by G. Huber in Lake Chrissie.

Cymbella amphicephala Naeg.
Sample 25.

Epithemia zebra Ehrenb.
Sample 31.

Rhopalodia gibba (Ehrenb.) O. Müller.
Sample 31.

Nitzschia hungarica Grun.
Sample 6.

Nitzschia microcephala Grun. var. *medio-constricta* Fritsch and Rich; Trans. Roy. Soc. S. Africa, 1929, xviii, fig. 10, *L.*
Samples 31, 35.

Nitzschia sigma (Kütz.) W. Sm.
Sample 38.

Nitzschia sp.
Sample 25.

Surirella sp.
Sample 11.

Campylodiscus clypeus Ehrenb.
Samples 31, 36.
Found by W. and G. S. West in the region of Lake Nyasa, and also said by them to be abundant in the April plankton of the Birket Qarun (Egypt).

CLASS V. CRYPTOPHYCEAE.

GROUP. CRYPTOMONADALES.

Genus Cryptomonas Ehrenb.

Cryptomonas sp.
Sample 31.

CLASS VI. DINOPHYCEAE.

Peridinium cinctum (Müll.) Ehrenb.
Sample 15 (very common). Found in this same locality by Huber-Pestalozzi.

Peridinium tabulatum (Ehrenb.) Clap. u. Lachm.
Samples 9, 13, 21, 25, 34.
In Florida Lake rather common in July, common in August; after that present, though rather rare, until May, when it was common again.

CLASS VIII. EUGLENINEAE.

Genus EUGLENA Ehrenberg.

Euglena acus Ehrenb. var. *longissima* Deflandre.
Sample 9.
12 μ broad ; more than 350 μ long.
Found in this lake also by Huber-Pestalozzi.

Euglena Ehrenbergii Klebs ; Lemmermann, Süsswasserfl., ii, 1913, p. 129, fig. 213.
Sample 8, on damp soil, therefore not planktonic.

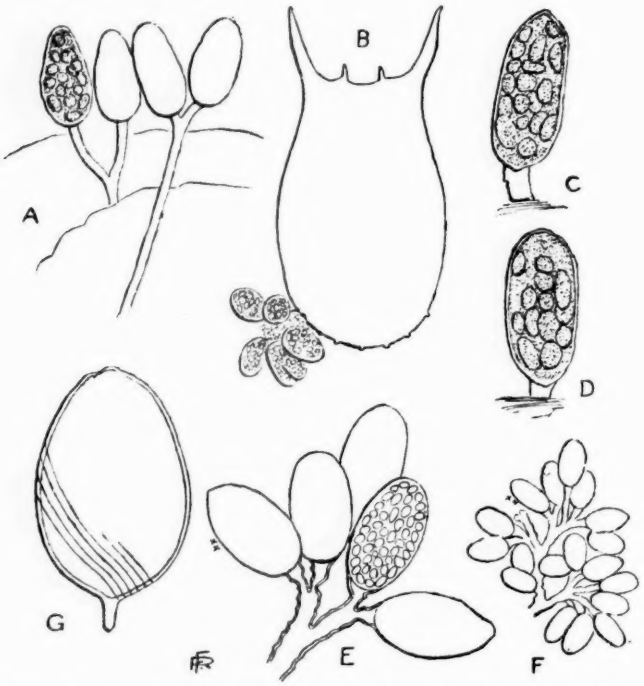


FIG. 18.—*A*, ? *Colacium arbuscula* (×770), *B*, *Anurea reducta* with epiphyte (×370). *C*, *D*, The epiphyte enlarged, ? *Colacium vesiculosum* (×1000). *E*, *F*, *Colacium* sp. ? (*E*, ×770; *F*, ×260). *G*, *Lepocinclis ovum* (Ehrenb.) Lemm. *forma* (×770).

Euglena oxyuris Schmarda *forma minor* Deflandre ; Fritsch and Rich, Trans. Roy. Soc. S. Africa, 1929, XVIII, fig. 24, *A*.
Samples 6, 13 (December), 14, 17, 21, 25.
This, the same form as was described in detail for Griqualand West, seems to be very widely distributed in South Africa.
The type recorded from the Cape and the Transvaal.

Euglena spirogyra Ehrenb. var. *marchica* Lemm.
Sample 6 (rare).
Other indeterminable species of *Euglena* occurred in samples 9 and 22.

Genus LEPOCINCLIS Perty.

Lepocinclis fusiformis (Carter) Lemm.
Samples 5, 6, 21.
Long., 34–38 μ ; lat., 20–25 μ.

Lepocinclis ovum (Ehrenb.) Lemm. ***forma*** (Fig. 18, *G*).
Samples 13 (October), 21.
In both these pieces of water rare individuals of what is possibly a separate variety were seen. No paramylon rings were visible. The little posterior spine had parallel sides, thereby differing from all published figures of this species.
Long. sine spin., 47–56 μ; lat., circa 38 μ; long. spin., 4–6 μ.
The type recorded from the Cape.

Lepocinclis Steinii Lemm.
Sample 25.
Long., 30 μ; lat., 14 μ.

Lepocinclis texta (Duj.) Lemm.
Sample 6 (rare).
Forma minor G. Huber.
Sample 21 (rare).
Recorded for the Cape and Transvaal.
Forma Fritsch and Rich, *op. cit.*, 1929, p. 73, fig. 25, *A*.
Sample 13 (January).

Genus Phacus Dujardin.

Phacus longicauda (Ehrenb.) Duj.
Samples 6, 17, 21.
Recorded from the Cape (Huber).
Var. *torta* Lemm. ***forma*** Fritsch and Rich, *op. cit.*, Pt. 1, 1929, fig. 25, *B–F*.
Samples 6, 13 (November).

Phacus pleuronectes (O.F.M.) Duj.
Samples 13 (August), 25 (May).
Recorded from Albert Nyanza.

Genus Trachelomonas Ehrenberg.

Trachelomonas armata (Ehrenb.) Stein.
Sample 25 (very rare).
Long., 34 μ; lat., 28 μ.
Var. *longa* Deflandre; Monogr. du genre Trachelomonas, 1926, p. 89, fig. 336.
Sample 25 (very rare).

Trachelomonas hispida (Perty) Stein.
Sample 22.
Recorded from Victoria Nyanza, the Cape, and the Transvaal.

Trachelomonas rugulosa Stein emend. Deflandre.
Samples 13 (April), 31.
Very few individuals seen.

Trachelomonas volvocina Ehrenb.
Samples 13 (April), 19.
Recorded from the Cape and Transvaal.

Genus Colacium Ehrenberg.

The three species below were on mounted slides so that an adequate investigation of the cell-contents was impossible; two of them agreed in other respects with the descriptions in Pascher's Süsswasserflora (*op. cit.*, ii, 1913, p. 155), but the determinations must be considered somewhat doubtful.

? *Colacium arbuscula* Stein (Fig. nostr. 18, *A*).
Sample 23, and Pool near Eliazer Pan.
Cells about 20 μ by 10 μ on long branched stalks, growing on a fragment that was indeterminable.

? *Colacium vesiculosum* Ehrenb. (Fig. nostr. 18, *B–D*).
Sample 24.
Cells with short, rather wrinkled stalks, growing on *Anurea reducta* G. Huber. Long., 20–23 μ; lat., 10–11 μ.

? *Colacium sp.* (Fig. 18, *E*, *F*).
Sample 23.

CLASS XI. MYXOPHYCEAE.

Genus Aphanothece Naegeli.

Aphanothece conglomerata spec. nov. (Fig. 19, *A–D*).
Familiis sphaericis parvis e cellulis 4 plerumque multis constantibus, pluribus in familiis majoribus aggregatis; cellulis bacilliformibus, 5–7 μ longis, 2 μ latis, polis rotundatis, contentu dilute aerugineo; involucris familiarum interdum paullo lamellatis, hyalinis.
Sample 35 (common), mixed with other members of the Myxophyceae.

The individual cells resemble those of *Aphanothece stagnina* (Sprengel) A. Br., but there is no record of the latter species forming composite colonies or having stratified sheaths.

Genus DACTYLOCOCCOPSIS Hansgirg.

Dactylococcopsis rhaphidioides Hansg.
Sample 6 (January, November).
Recorded from Victoria Nyanza.

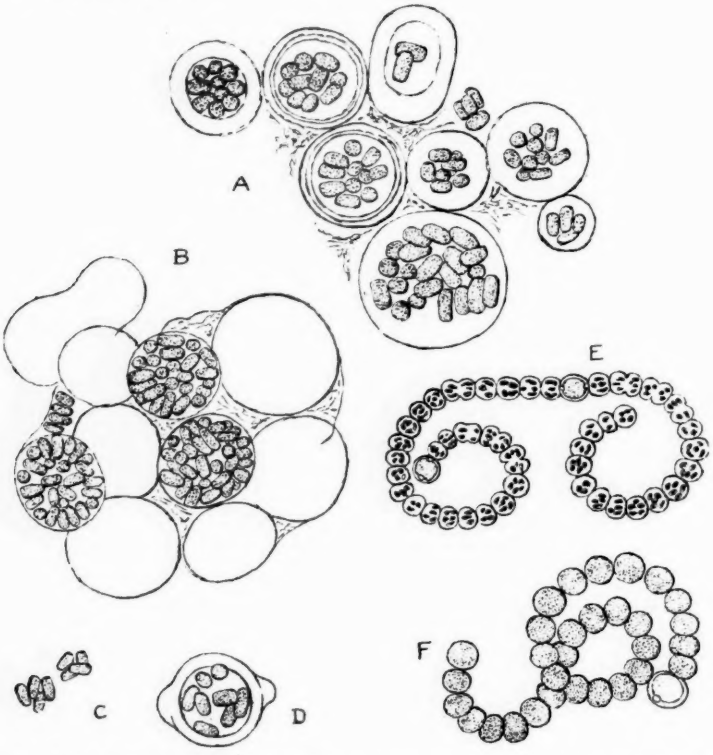


FIG. 19.—*A–D, Aphanothece conglomerata* sp. nov. (×nearly 1000 times). *E, F, Anabaena spiroides* Klebahn *forma* (×770).

Genus MERISMOPEDIA Meyen.

Merismopedia glauca (Ehrenb.) Naeg.
Sample 6 (August, November).
Recorded from Tanganyika, Victoria Nyanza, and the Transvaal.

Merismopedia tenuissima Lemm.
Sample 35.

Genus COELOSPHAERIUM Naegeli.

Coelosphaerium Kützingianum Naeg.
Sample 25 (rather rare).
Recorded from Victoria Nyanza.

Genus GOMPHOSPHAERIA Kützing.

Gomphosphaeria aponina Kütz.; Lemmermann, Kryptogamenflora der Mark Brandenburg, p. 44, fig. 18.
Sample 8. This Alga was found by D. Weintroub growing on damp soil and is therefore not planktonic.
Recorded from Tanganyika.

Genus MICROCYSTIS Kützing.

Microcystis aeruginosa Kütz.
Sample 16.
Recorded from Nyasa, Victoria Nyanza, the Cape, and the Transvaal.

Microcystis firma (Bréb. et Lenorm.) Rabenh.
Sample 20.
Previously recorded from Nyasa.

Microcystis flos-aquae (Wittr.) Kirchn.
Samples 6, 13, 14, 15, 23, 24, 30, 35, 37.
The colonies were not clathrate in any of the above samples; this character seems to be the only point of difference between this species and *M. aeruginosa* Kütz.
Recorded from Victoria Nyanza. Apparently very widely distributed in South Africa.

Microcystis pulverea (Wood) Migula.
Sample 4.

Genus GLOEOCAPSA Kützing.

Gloeocapsa sp. present in De Villiers Reservoir but only in small quantities.

Genus APHANOCAPSA Naegeli.

Aphanocapsa Elachista W. and G. S. West var. *conferta* W. and G. S. West.
Sample 13 (December, January).

Aphanocapsa Grevillei (Hass.) Rabh.
Sample 18.

Genus CHROOCOCCUS Naegeli.

Chroococcus dispersus (v. Keissler) Lemm.
Sample 35.

Chroococcus irregularis G. Huber.
Sample 9.
Cells usually four together; diameter of cells, 6–8 μ.
Found by G. Huber in Blaauwater.

Chroococcus minutus (Kütz.) Naeg.
Sample 36.

GROUP. HORMOGONEALES.

Genus OSCILLATORIA Vaucher.

Oscillatoria splendida Greville; Gomont, Monographie des Oscillariées, Pl. VII, figs. 7, 8.
Sample 25 (July, rare).
Recorded from Nyasa.

Oscillatoria sp. was noticed in Florida Lake (July) but it was too scanty for determination.

Genus SPIRULINA Turpin.

Spirulina subtillissima Kütz.
Sample 6 (August.)

Genus LYNGBYA Agardh.

? *Lyngbya Birgei* Smith; Wisconsin Phytoplankton, 1920, Pl. VII, figs. 14–15.
Sample 38. Very little seen; no pseudo-vacuoles observed; according to G. M. Smith these are usually present.

Genus NODULARIA Mertens.

Nodularia spumigena Mertens var. *vacuolata* Fritsch and Rich (Fig. nostr. 20, *D*).
Sample 3 (abundant).
In Griqualand West it was noticed that the spores were produced singly (Fritsch and Rich, Trans. Roy. Soc. S. Africa, 1929, xviii, fig. 30, *H–I*); here they were found three or four in series (see Fig. 20, *D*). A narrow sheath was visible closely applied to the trichome. The wall of the spore was brown.
Trichomes 8–9 μ wide; spore 11–12 μ wide.

Genus ANABAENA Bory.

Anabaena affinis Lemm. *forma minor* (Fig. 20, *C*).
Sample 13 (December).
Filaments solitary, cells with pseudo-vacuoles, round, 4 μ in diameter. Heterocysts round, or slightly elongated, about as wide as the vegetative cells. Spore remote from the heterocysts; in shape, an elongated ellipse 8 μ wide, 11 μ long. The wide gelatinous envelope was difficult to see. This form only differs from *Anabaena affinis* in its smaller dimensions.

Anabaena spiroides Klebahn, *forma* (Fig. 19, *E*, *F*).

Samples 14, 15, 23, and 24.

Since no spores were present the determination is based on vegetative material only. G. S. West says (Linn. Soc. Journ., Bot., 1907, xxxviii, p. 169) that the form of *Anabaena flos-aquae* described by him for Tanganyika may be identical with *A. spiroides*. His figure (*loc. cit.*, Pl. X, fig. 1) is very like the form in the present samples. West remarks that this was the dominant feature of two of the Nyasa plankton collections. (He adds that the heterocysts were never observed to be terminal, but here in Weltevreden East and Riet Kuil it was noticed that they sometimes were. See Fig. 19, *E*, *F*.)

The trichomes are rather irregularly twisted, not in regular spirals. Cells 5–6 μ in diameter; heterocysts 6–7 μ Schmidle (1902) records a form similar to the present under *Anabaena flos-aquae*.

Genus SCYTONEMA Agardh.

Scytonema sp. A fragment was observed in De Villiers Reservoir, but there was not enough to determine. It was intermingled with *Gloeocapsa* sp.

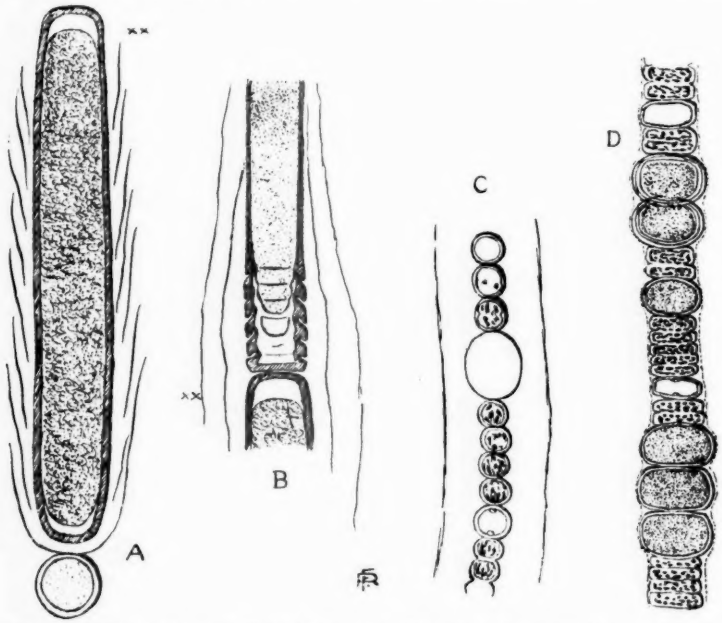


FIG. 20.—*A*, *B*, *Gloeotrichia natans* (Hedw.) Rabenh. (×770). *C*, *Anabaena affinis* Lemm. *forma minor*. *D*, *Nodularia spumigena* Mertens var. *vacuolata* Fritsch and Rich. (*C*, *D*, ×1000.)

Genus GLOEOTRICHIA Agardh.

Gloeotrichia natans (Hedw.) Rabenh. (Fig. nostr. 20, *A*, *B*.)

Sample 25 (rather rare).

Spores 100×16 μ; 110×20 μ.

Recorded from the plankton of Rukuga by Schmidle.

THE GENUS *ANTHEPHORA*, Schreb.

By A. P. Goossens, M.Sc.,
Botanist, National Herbarium, Pretoria.
(Communicated by E. P. Phillips.)

(With four Text-figures.)

The South African species of the genus *Anthephora* were last monographed by Stapf in Thistleton-Dyer's "Flora Capensis," vol. vii, p. 440. In 1930 Stapf and Hubbard monographed the tropical African species in Prain's "Flora of Tropical Africa," vol. ix, pt. 5, in which were included the species of the South-West African Protectorate.

As much fresh material has accumulated in the South African herbaria, and as there appeared to be undescribed species which were still retained under *A. pubescens*, and which were not described by Stapf and Hubbard in their recent work, the writer thought it advisable to bring the local material up to date as well.

The Directors of the South African, Albany, and Transvaal Museums, Prof. Geo. Potts of the Grey University College, the Curator of the Bolus Herbarium, and the Mycologist in charge of the Natal Herbarium all very kindly placed their collections at my disposal. These collections, together with the material in the National Herbarium, Pretoria, gave me a fair opportunity of studying the South African representatives of the genus. I am also very much indebted to Dr. I. B. Pole Evans, C.M.G., to Miss S. M. Stent, and to Dr. E. P. Phillips for their kind assistance and criticism, also to Miss I. C. Verdoorn for her assistance with the Latin translations and to Miss Cythna Letty for figuring the specimens.

The genus *Anthephora* was established by Schreber (Beschr. Gräs. ii, 105, t. 44) in 1779 on a Mexican plant which he named *A. elegans*. Hackel (1896) placed the genus in the small tribe *Zoysieae* which he included in the *Panicoideae*, for he regarded the tribe allied to the *Andropogoneae* since the valves (lemmas) and pales (paleae) are membranous to hyaline and therefore thinner in texture than the coriaceous lower glumes. Stapf has rightly placed it under the *Paniceae* (Stapf in Prain's Flor. Trop. Afr., ix) since the lower lemma is empty; but Bews (1929) has retained it in the *Zoysieae*.

There are about 18 species of the genus adapted to dry conditions in the warmer parts of Africa, America, and Persia. In Africa the genus is represented by about 15 species extending from tropical Africa through tropical West Africa into the South-West African Protectorate, and from there through the northern arid districts of the Cape Province into Griqualand West, the Orange Free State, Bechuanaland, and the Transvaal.

The habit of the species varies considerably, and it was principally on the variations in habit that specimens in herbaria included under *A. pubescens* Nees could be separated into distinct species. Two of the species, which are described in the following pages, viz., *A. ramosa* and *A. angustifolia*, and which are closely related to *A. nigritana* Stapf and Hubb., have the culms very evidently branched, while *A. argentea* is a very slender wiry grass with a slender flexuous and silvery-villous false spike, and is a near ally of *A. pubescens* Nees. Another ally of the latter is *A. aequiglumis*. Only two specimens of the latter have been collected from the Sandveld area in the Hoopstad and Kroonstad districts, Orange Free State. It is a very interesting species in that the false spike is interrupted with the branches on the lower half of the rachis about 7–15 mm. long, while those in the upper half are markedly reduced, approaching the type of clusters of spikelets we find in *A. pubescens*. Another important difference between the two is that in the former the glumes are subequal and do not form a spurious involucre. Several specimens of *A. pubescens* have the lower glume villous with simple hairs, and such specimens are more or less confined to the South-West African Protectorate. The great majority of the specimens of this species, however, have the lower glume of the spikelets villous with tubercle-based hairs, and are more or less grouped in Griqualand West and Bechuanaland extending into the Orange Free State and the Transvaal. The latter specimens also have purplish-coloured lower glumes. Whether the nature of the hairs is as much a Mendelian character as the colouration is not quite clear, but apart from the nature of the hairs it was not possible to find another outstanding character by which to separate the two types into distinct species. In *A. pubescens* the clusters of spikelets are composed of a varying number of spikelets, viz., 5–9, and this variation was not only observed in different specimens, but also on the same false spike. The nervation of the lower glumes and the valves also varied; in the former from 2–8 and in the latter from 3–9. Very often the lower glume of the central spikelet of a cluster was very much reduced and often wanting.

The false spikes, composed of subsessile deciduous clusters of spikelets with a protecting involucre formed from the lower glumes, and the spreading bulbous-based hairs on the back of the lower lemma, are the outstanding characters of the genus.

ANTHEPHORA Schreb.

Spikelets 2–many, in subsessile deciduous squarrose or oblong clusters. *Flower* 1, bisexual or male. *Glumes* very dissimilar in texture and shape, rarely subequal; lower firmly coriaceous, rarely subcoriaceous, oblong to lanceolate, obtuse or long-acuminate, with the tips suberect or horizontally spreading, 2–8-nerved, with the nerves only visible on the inside (in the inner spikelets of a cluster the lower glume is reduced, hyaline to coriaceous, 1-nerved or nerveless, or sometimes absent); upper hyaline, setaceously acuminate from a short ovate base, or linear and obtuse to subobtuse or linear-lanceolate, mostly shorter than the lower glume, 1–3-nerved. *Lemmas* 2; lower hyaline, sterile, usually shorter or sometimes subequal to or rarely longer than the lower glume, usually oblong, dorsally compressed, 3–9-nerved; upper membranous to subchartaceous, subtending a bisexual or male flower with or without a rudimentary ovary. *Pale* of the lower lemma 0; of upper lemma similar in texture and shape to its lemma, usually glabrous. *Lodicules* 2. *Stamens* 3; *Anthers* linear. *Ovary* usually lanceolate-oblong in outline; stigmas plumose, subapically exserted. *Grain* dorsally compressed, oblong in outline, enclosed in the spikelet; hilum punctiform; embryo usually about half the length of the grain.

Perennials or annuals; culms tufted, erect or geniculately ascending from a prostrate base, simple or branched; ligule scarious; leaf-blade linear, flat, or sometimes folded; inflorescence a cylindric false spike bearing the spikelets in deciduous clusters with the lower glumes forming a false involucre with gaps between their bases.

Species 18, *in Tropical and South Africa, South Persia, and Tropical America.*

Key to the South African Species of the Genus Anthephora.

Perennial: leaves 9–35 cm. long.

Culms branched from the upper nodes; glumes dissimilar; lower glumes equal to or only slightly exceeding the lemmas, suberect, villous on the back with simple hairs to subglabrous.

Leaves up to 22·5 cm. long, 4–7 mm. wide; uppermost internode up to 26 cm. long; ligule 3–5·5 mm. long; glumes loosely villous to subglabrous; cilia on lower lemma 1·5–1·75 mm. long . . . . . 1. *A. ramosa* n. sp.

Leaves up to 15 cm. long, 2–2·5 mm. wide; uppermost internode 30–40 cm. long; ligule 5–6 mm. long; glumes densely villous; cilia on lower lemma 1·75–3 mm. long. . . . . 2. *A. angustifolia* n. sp.

Culms simple; glumes dissimilar, rarely subequal; lower glumes usually evidently exceeding the lemmas, with the tips ultimately subhorizontally spreading or rarely suberect, rarely shorter than the lemmas but then the glumes subequal, densely villous with simple or tubercle-based hairs.

The branches of the rachis in the lower clusters of spikelets 7–15 mm. long; the glumes subequal . . . . . 3. *A. aequiglumis* n. sp.

The branches of the rachis reduced to stumps; the glumes very dissimilar.

False spike 5–15 cm. long, 3–6 mm. in diameter, erect; lower glumes distinctly long acuminate, with the tips subhorizontally spreading; upper lemma glabrous; pale setaceous acuminate from a short ovate base, 1-nerved; ligule up to 5 mm. . . . . 4. *A. pubescens.*

False spikes up to 7 cm. long, 2–2·5 mm. in diameter, flexuous; the lower glume suberect, not evidently long acuminate; upper lemma hirsute near the apex; pale linear, 2-nerved; ligule 5–8 mm. long.

5. *A. argentea* n. sp.

Annual: leaves 2·5–5 cm. long.
Culms fasicled, erect; lower glume 8–10 mm. long, prominently long acuminate. 6. *A. undulatifolia.*
Culms very loosely tufted, geniculately ascending; lower glume up to 4 mm. long, subobtuse, or very shortly acuminate, shortly mucronate . . 7. *A. Schinzii.*

1. *A. ramosa* Goossens sp. nov.

(Text-fig. 1.)

Gramen perenne, dense caespitosum. *Culmi* erecti vel geniculati, ramosi, glabri, laeves, 3–8-nodi, nodis superioribus *c.* 26 cm. longis. *Foliorum vaginae* inferiores laterale compressae, carinatae, ad basin villosae sed saepe tuberculatae, glabrae et ad apicem laeves, striatae; superiores 10–12 cm. (rare *c.* 15 cm.) longae, gracile striatae, laxae, glabrae sed saepe ad basin sparse villosae (pilis ad basin tuberculatis); ligulae scariosae, 3–5·5 mm. longae, obtusae. *Laminae* rigidae, *c.* 22·5 cm. longae, *c.* 7 mm. latae, lineares, apice acutae, base contractae, planae, glabrae vel villosae (pilis aliquando tuberculatis) scaberulae. *Inflorescentia* 8·5–10·5 cm. longa, *c.* 4 mm. lata, erecta. *Rachis* distincte sinuata, triquetra, glabra vel nodis barbata, laevis; rami valde contracti, apice calyculati. *Fasciculae spicularum c.* 7 mm. longae, 2 mm. latae, sparse adpresso-pilosae, base barbatae, 5–7-spiculatae. *Spiculae* 1-florae, 5–6·5 mm. longae. *Glumae* 2, inaequales; inferior coriacea, *c.* 1·5 mm. lata, lanceolata, apice acuta, suberecta, sparse dorso villosa, 2–5-nervata; superior hyalina, 3·5–4·75 mm. longa, ovata, setaceo-acuminata, ciliata, 1-nervata. *Lemmata* 2; inferior hyalinum, sterilis, 4–4·75 mm. longum, oblongo-lanceolatum, apice acutum, 3–5-nervatum, ciliatum, supra medium utrinque pilosum (pilis 1·5–1·75 mm. longis patentibus ad basin tuberculatis), infra medium puberulum; superior membranaceo-chartaceum, ♀ vel ♂, 4–4·5 mm. longum, oblongo-lanceolatum, apice acutum, glabrum vel sparse ciliatum vel apice scaberulum, 3-nervatum. *Palea* lemmatis inferioris 0; lemmatis superioris lemmati in textu et forma similis, glabra. *Antherae* 2·5 mm. longae. *Caryopsis* oblonga, dorso-compressa.

South-West Africa.—Norûdas Süd: Groot Karasberg, among granite blocks in ravine, *Pearson* 8535 !. Klein Karasberg, western foothills near Holoog, *Pearson* 9739 !. Gründoorn, middle slopes of kopje in pass, *Pearson* 3126 !. Klein Karas, *Dinter* 5090 !.

Cape Province.—Gordonia dist.: Karreeboom Mountains, *Pole Evans* 2407 (type); 2060 !.

A tufted perennial. *Culms* erect or geniculately ascending, up to 68 cm. long, branched, terete, or shallowly grooved near the base on the side facing the branch, glabrous smooth, 3–8-noded, with the uppermost internode up to 26 cm. long. *Basal sheaths* laterally compressed, keeled, villous at the base with simple or often with tubercle-based hairs, glabrous and smooth higher up, striate; upper sheaths 10–12 cm. (rarely up to 15 cm.) long, usually shorter than the internodes, glabrous or often with scattered bulbous-based hairs, finely striate, not tightly enveloping the culms; ligule scarious, 3–5·5 mm. long, obtuse; blades firm up to 22·5 cm. long, up to 7 mm. wide, linear from a slightly contracted base, finely acute, flat, scaberulous, glabrous or with scattered simple or bulbous-based hairs, with a prominent midrib on the upper surface and with cartilaginous sinuate margins. *Inflorescence* 8·5–10·5 cm. long, about 4 mm. wide, erect. *Rachis* distinctly wavy, triquetrous, bearded at the nodes, sometimes becoming glabrous; branches of rachis reduced to minute cupular stumps. *Clusters of spikelets* about 7 mm. long, 2 mm. wide, slightly constricted just above the middle, laxly adpressed hairy, bearded at the base, composed of 5–7 spikelets. *Spikelets* 1-flowered, 5–6·5 mm. long. *Glumes* very dissimilar in shape and texture; lower coriaceous, as long as the spikelet, up to 1·5 mm.

wide, lanceolate acute, suberect, sparsely hairy on the back with simple hairs, 2–5-nerved, with the nerves only visible on the inside; upper hyaline, 3·5–4·75 mm. long, setaceously acuminate from a short ovate base, ciliate, 1-nerved. *Lemmas* 2; lower hyaline, empty, 4–4·75 mm. long, oblong-lanceolate, acute, dorsally compressed, with

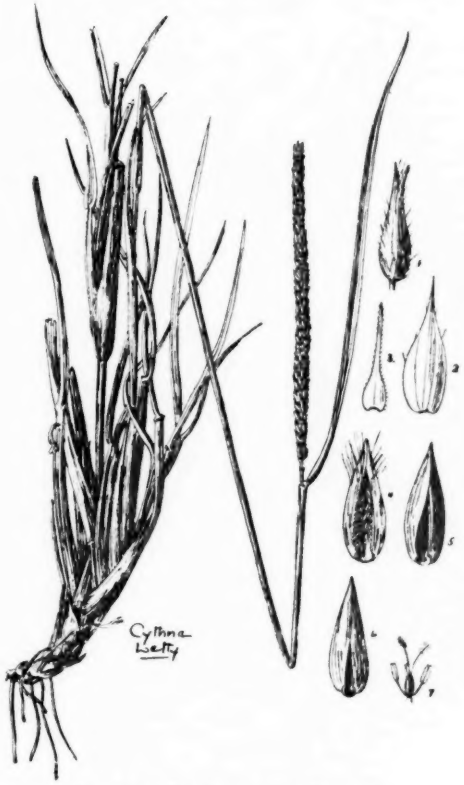


FIG. 1.—*Anthephora ramosa* Goossens.
1. Spikelet. 2. Lower glume. 3. Upper glume. 4. Lower lemma. 5. Upper lemma. 6. Pale. 7. Flower.

inflexed ciliate margins, long-ciliate in the upper half with spreading bulbous-based hairs 1·5–1·75 mm. long, puberulous below, 3–5-nerved; upper membranous to subchartaceous, subtending a bisexual or male flower, 4–4·5 mm. long, lanceolate to oblong-lanceolate, acute, glabrous or slightly ciliate or scaberulous at the apex, 3-nerved. *Pale* of lower lemma 0; of upper lemma similar in texture and shape to its lemma, glabrous. *Anthers* 2·5 mm. long.

Closely related to *A. nigritana* Stapf and Hubb., from which it differs in having the

culms branched; the leaves longer and wider; the ligule longer; the glumes smooth and loosely villous; the lower lemma 3–5-nerved.

2. *A. angustifolia* Goossens sp. nov.

(Text-fig. 2.)

Gramen perenne, laxe caespitosum. *Culmi* erecti, c. 84 cm. alti, ramosi, subgraciles, glabri, laeves sed infra spicem scaberuli, 3-nodi, nodis superioribus 30–40 cm. longis.

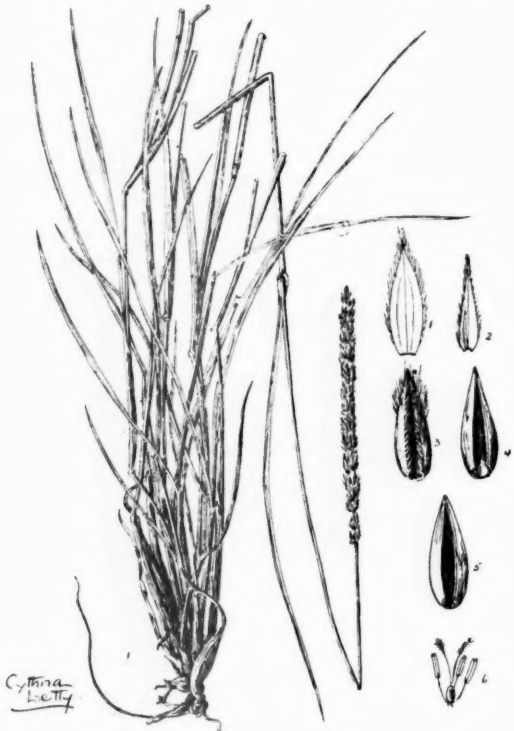


FIG. 2.—*Anthephora angustifolia* Goossens.
1. Lower glume. 2. Upper glume. 3. Lower lemma. 4. Upper lemma. 5. Pale. 6. Flower.

Foliorum vaginae inferiores *c.* 5 cm. longae ad apicem glabrae et laeves, in basin adpresso-pilosae; superiores *c.* 18·5 cm. longae, glabrae, laeves; ligulae scariosae, 5–6 mm. longae, obtusae. *Laminae c.* 15 cm. longae, 2–2·5 mm. latae, lineares vel linear-lanceolatae, acuminatae, apice acutae, base contractae, glabrae et laeves, marginibus sinuatis.

Inflorescentia *c.* 10·5 cm. longa, *c.* 4 mm. lata, flexuosa. *Rachis* distincte sinuata, triquetra; rami valde contracti. *Fasciculae spicularum* 7 mm. longae, *c.* 2 mm. latae, base dense barbatae, villosae, 5-spiculatae. *Spiculae* 1-florae, 6 mm. longae. *Glumae* inaequales; inferior coriacea, 6 mm. longa, 1·5 mm. lata, lanceolata, acuta, dense villosa pilis simplicibus, 3–4-nervata; superior hyalina, 5 mm. longa, linear-lanceolata, obtusa, 1-nervata, sparse villosa, carino et margine ciliato. *Lemmata* 2; inferior hyalinum, sterilis, *c.* 5 mm. longum, 1·5 mm. latum, oblongo-lanceolatum, apice acutum, 3-nervatum, ciliatum, supra medium utrinque pilosum (pilis 1·75–3 mm. longis ad basin tuberculatis); superior membrenaceo-chartaceum, ♀ vel ♂, *c.* 5 mm. longum, lanceolatum, supra basin glabrum, apicem scaberulum, 3-nervatum. *Palea* lemmatis inferioris 0; lemmatis superioris lemmati in textu et forma similis. *Antherae* 3·25 mm. longae.

Cape Province.—Gordonia dist.: *Pole Evans* 2060 !. (type).

A loosely tufted perennial. *Culms* erect, up to 84 cm. long, branched, more or less slender, terete or shallowly grooved near the base on the side facing the branch, 3-noded with the uppermost internode 30–40 cm. long and minutely scaberulous just below the inflorescence, otherwise glabrous and smooth. *Basal sheaths* up to 5 cm. long, shortly adpressed-hairy at the base, glabrous and smooth above, striate; upper sheaths up to 18·5 cm. long, shorter than the internodes, finely striate, glabrous, smooth, not tightly enveloping the culms; ligule scarious, 5–6 mm. long, obtuse; blades up to 15 cm. long, 2–2·5 mm. wide, linear to linear-lanceolate from a slightly contracted base, tapering to an acute point, folded, finely striate, glabrous, smooth, with cartilaginous and slightly sinuate margins. *Inflorescence* up to 10·5 cm. long, about 4 mm. in diameter, flexuous. *Rachis* distinctly wavy, triquetrous, glabrous, smooth; branches reduced to minute stumps. *Clusters of spikelets* 7 mm. long, about 2 mm. wide, densely bearded at the base, villous, composed of 5 spikelets with the tips of the lower glumes suberect. *Spikelets* 1-flowered, 6 mm. long. *Glumes* very dissimilar in texture and shape; the lower coriaceous, 6 mm. long, 1–5 mm. wide, lanceolate, acute, suberect, densely villous on the back with simple hairs, 3–4-nerved, with the nerves only visible on the inside; upper hyaline, 5 mm. long, linear, obtuse, sparingly villous, ciliate on the keel and on the margins, 1-nerved. *Lemmas* 2; the lower hyaline, sterile, about 5 mm. long, 1·5 mm. wide, oblong-lanceolate, acute, dorsally compressed with inflexed and ciliate margins, long-ciliate in the upper half with bulbous-based hairs 1·75–3 mm. long, 3-nerved; upper membranous to subchartaceous, subtending a bisexual or male flower, about 5 mm. long, lanceolate, scaberulous above, glabrous below, 3-nerved. *Pale* of the lower lemma 0: of upper similar in texture and shape to its lemma. *Anthers*, 3·25 mm. long.

Closely related to *A. ramosa*, but is distinguished from it in being loosely tufted; the uppermost internode is much longer; the leaves are shorter and narrower; the lower glumes are densely villous; and the cilia on the lower lemma are longer.

3. *A. aequiglumis* Goossens sp. nov.

(Text-fig. 3.)

Gramen perenne, dense caespitosum. *Culmi* geniculato-adscendentes ex breve descendate rhizomate, usque 120 cm. alti, subvalidi, teretes, simplices, glabri, 3–4-nodi. *Foliorum vaginae* inferiores internodiis aequales vel quam internodiis longiores, dense adpresso-pilosae vel villosae, circa orem barbatae; superiores quam internodiis breviores, laterale compressae, carinatae, dense hirsutae vel pubescentes vel ad apicem glabrae; summa glabra, circa orem barbata, quam internodiis multum breviores; ligulae subhyalinae, usque 5 mm. longae. *Laminae* usque 20 cm. longae, 3 mm. latae, lineares, setaceo-acuminatae, acutae, striatae, tenuiter scaberulae, glabrae vel solum ad basin

post ligulam dense hirsutae vel pubescentes. *Inflorescentia* 9-10 cm. longa, usque 7 mm. lata, erecta, cylindrica, spicata, dense villosa; rachis gracilis, sinuata, triquetra, glabra

FIG. 3.—*Anthephora aequiglumis* Goossens.
1. A cluster of spikelets. 2. A spikelet. 3. Lower glume. 4. Upper glume. 5. Lower lemma. 6. Upper lemma. 7. Pale. 8. Flower.

vel ad nodum barbata, secus angulares scaberula; rami ·75–15 mm. longi, triquetri, pilosi. *Fasciculae spicularum* usque 11 mm. longae, ad basin barbatae, 2-multispiculatae; inferiores multispiculatae; superiores 2-spiculatis diminuatae. *Spiculae* 1-florae, usque 4 mm. longae, breve pedunculatae et subunilaterales. *Glumae* 2 subaequales; inferior subcoriacea, 3 mm. longa, ovato-lanceolata, acuminata, acuta, dorso-

villosa, secus margines breviore et rigida ciliata, 1–3-nervata; superior membrenacea, 2·75 mm. longa, lanceolata, acuminato-acuta, dorso dense villosa, secus margines ciliata, 3-nervata. *Lemmata* 2; inferior submembrenaceum, sterilis, usque 3·5 mm. longum, oblongo-lanceolatum, acuminatum, apice acutum, 7-nervatum, supra medium utrinque pilosum (pilis patentibus, usque 1·25 mm. longis, ad basin tuberculatis); superior subchartaceum, ♂, usque 3·25 mm. longum, lanceolatum, acuminatum, apice acutum, glabrum, ad apicem scaberulum, 3-nervatum. *Palea* lemmatis inferioris 0; lemmatis superioris lemmati in textu et forma similis, glabra. *Antherae* usque 2·25 mm. longae.

Orange Free State.—Hoopstad dist.: Odendaalsrust, on an open plot, *Schultz in Nat. Herb.* 8344 !. Kroonstad dist.: Groenebloem, *Potts* 2674 !.

A densely tufted perennial with intravaginal innovations. *Culms* geniculately ascending from a short descending rhizome, up to 120 cm. high, more or less stout, terete, simple, glabrous, 3–4-noded. *Leaf-sheaths*: the lower as long as or exceeding the internodes, densely adpressed hairy to villous, bearded at the mouth; the upper shorter than the internodes laterally compressed keeled, densely hirsute to pubescent or glabrous towards the apex; the uppermost bearded at the mouth and glabrous further down, much shorter than the internode; ligule subhyaline, about 5 mm. long; blades up to 20 cm. long, 3 mm. wide, linear, setaceously acuminate, acute, striate, finely scaberulous on upper surface, glabrous or only densely hirsute or pubescent on the upper surface at the base behind the ligule. *Inflorescence* 9-10 cm. long, up to 7 mm. wide, cylindric, spikelike, erect, densely villous; rachis slender, sinuate, triquetrous, glabrous except at the bearded nodes, scabrid along the angles; branches ·75–15 mm. long, triquetrous, hairy. *Clusters of spikelets* up to 11 mm. long, composed of 2–many spikelets, bearded at the base; the lower composed of many spikelets; the upper clusters decreasing to 2 spikelets. *Spikelets* 1-flowered, up to 4 mm. long, shortly peduncled and subsecund. *Glumes* subequal; lower subcoriaceous, 3 mm. long, ovate, lanceolate-acuminate, acute, densely villous on the back, shortly and rigidly ciliate on the margins, 1–3-nerved; the upper membranous, 2·75 mm. long, lanceolate, acuminately acute, densely villous on the back, shortly ciliate on the margins, 3-nerved. *Lemmas* 2; lower thinly membranous, striate, about 3·5 mm. long, oblong-lanceolate, acuminate, acute, dorsally compressed, with inflexed margins, long ciliate in the upper half with spreading bulbous-based hairs up to 1·25 mm. long, 7-nerved; upper subchartaceous, subtending a bisexual flower, about 3·25 mm. long, lanceolate, shortly acuminate, acute, glabrous, scaberulous at the apex, 3-nerved. *Palea* of the lower lemma 0; of upper similar in texture and shape to its lemma, glabrous. *Anthers* about 2·25 mm. long, linear.

Closely related to *A. pubescens* Nees, from which it differs in that the branches of the rachis (at least in the lower part) are distinctly elongated and about 7 mm. long; the glumes are subequal and are shorter than the lemmas, and neither do they form a false involucre.

4. *A. pubescens* Nees, Fl. Afr. Austr., 74; Durand and Schinz, Consp. Fl. Afr., v, 732; Steud., Syn. Pl. Glum., i, 111; Stapf, Dyer Fl. Cap., vii, 440; Garabedian, Ann. S. Afr. Mus., xvi, 395; Stent in Bothalia, i, 255; Stapf and Hubbard in Prain Fl. Trop. Afr., ix, pt. v, 943. *Tripsacum pubescens* Licht. ex Nees, Fl. Afr. Austr., 74. *Cenchrus pubescens* Steud., Nomencl. Bot., ed. 2, i, 317.

In the South African specimens examined, it was found that the clusters of spikelets are composed of 5–9 spikelets; the lower glume is 2–8-nerved and the lower lemma 3–9-nerved.

Common name: *Borseltjie gras*. It is considered to be one of the best pasture grasses in the parts where it occurs.

South-West Africa.—Gründoorn, middle slopes and kopjes above the pass, *Pearson* 3126 !. Between Haris and Aub, on high plateau, *Pearson* 9670 !. Muragas, *Lightfoot* 12738 !. Otjikondo, *Thorne in S. Afr. Mus.*, 31767 !. Gogabis on dunes, *Wilman in S. Afr. Mus.*, 18380 !. Between Karos and Kammanjab, *Thorne in S. Afr. Mus.*, 31766 !. Between Haris and the Awas Mountains, on plateau, *Pearson* 9502 !. Okahandja, at Quickborn Farm, *Bradfield* 284 !. Between Gogabis and Gaikas, *Gillman* 32 !.

Cape Province.—Hay dist.: Postmasburg, *Uys* G9 !. Gordonia dist.: near Upington, *Borchards in Nat. Herb.*, 21520 !; *Pole Evans* 2059 !. Prieska dist.: on dry pan soil, *Bryant* K31 !. Barkley West dist.: *Bennie* 587 !; 630 !. Kimberley dist.: *Moran in Bolus Herb.*, 19367 !. Vryburg dist.: *Pole Evans* 2394 !; *Sharpe in Nat. Herb*, 274 !; *Stent in Nat. Herb*, 21508 !; *Theiler in Nat. Herb*, 20209 !

Orange Free State.—Hoopstad dist.: *Parkes in G.U.C. Herb*, 1142 !. Bloemfontein dist.: veldgrazing experimental plots, *Glen in Nat. Herb*, 3421 !; south of town on red sandy soil, *Potts* 1253 !; on road to Dealesville, *Potts* 2449 !; *Rogers* 771 !. Kroonstad dist.: at Holfontein, *Hall* 69 W !; *Pont* 331 !. Without locality, *Rehmann* 3662 !, 3500 !; *Burchell* 1984 !.

Bechuanaland.—Muchudi, *Rogers* 6576 !; 6324 !; *Harbor in Natal Herb.*, 15837 !; *in Bolus Herb*, 19368 !. Gaberones, *Van Son in Tvl. Mus.*, 28640 !.

Transvaal.—Christiana dist.: *Burtt-Davy* 12836 !. Bloemhof dist.: *Burtt-Davy* 11348 !. Wolmaranstad dist.: *Sutton* 70 !; Maquassi, *Rogers* 20652 !. Pretoria dist.: at the Fountains valley, *Skea* 45 !; Onderstepoort, *Vet. Research* 10 !. Lydenburg dist.: *Atherstone in S. Afr. Mus.*, 19285 !.

5. *A. argentea* Goossens sp. nov.

(Text-fig. 4.)

Gramen perenne, caespitosum. *Culmi c.* 74 cm. longi, graciles, 2–3-nodi, glabri. *Foliorum vaginae* inferiores *c.* 6 cm. longae, pubescentes vel glabrescentes; superiores *c.* 13·5 cm. longae, glabrae, laeves, striatae; ligulae scariosae, 5–8 mm. longae. *Laminae c.* 19 cm. longae, 1–2 mm. latae, lineares, acuminatae, acutae, glabrae, laeves, striatae. *Inflorescentia c.* 7·5 cm. longa, 2–2·5 mm. lata, gracilis, flexuosa, argenteo-villosa. *Rachis* gracilis, sinuata, angularis; rami valde contracti, apice calyculati. *Fasciculae spicularum c.* 8 mm. longae, argenteo-villosae, 5-spiculatae. *Spiculae* 1-florae, *c.* 7 mm. longae. *Glumae* inaequales; inferior coriacea, *c.* 7 mm. longa, *c.* 2 mm. lata, lanceolata vel eliptico-lanceolata, setaceo-acuminata, integra vel 2-lobata, 3–5-nervata, nervibus lateralibus percurrentis et ad apicem crassis vel acute curvis et medium nervum decurrentibus; superior membranacea, 3–5·25 mm. longa, linearis vel linear-lanceolata, sparse et breve villosa, 1–2-nervata, ciliata. *Lemmata* 2; inferior hyalinum, sterilis, 4–5·5 mm. longum, 1–1·5 mm. latum, oblongo-lanceolatum, 3-nervatum, dorso compressum, integrum vel 2-lobatum, saepe apicibus scaberulis mucronatis et marginibus inflexis, supra medium utrinque pilosum (pilis 2·25 mm. longis ad basin tuberculatis); superior subchartaceum, ♀ vel ♂, 4·25–5 mm. longum, ·75 mm. latum, lanceolatum, acutum, ad basin glabrum, supra medium sparse villosum vel scaberulum, 2–3-nervatum. *Palea* lemmatis inferioris 0; lemmatis superioris lemmati in textu et forma similis, glabra vel ad apicem hirsuta. *Antherae* 2·75 mm. longae.

Cape Province.—Gordonia dist.: between Vuilnek and Inkruip, on dunes, *Pole Evans* 2409 !. Hay dist.: near Dunmurry, on sides of kloof, *Wilmann* 2203 ! (type). Kuruman dist.: on the Kuruman Hills, *Pole Evans* 2415 !.

A tufted perennial with intravaginal innovations. *Culms* up to 74 cm. long, slender, terete, wiry, geniculately ascending from a rhizome enveloped by the old leaf-sheaths,

simple, glabrous, smooth, 2–3-noded, with the uppermost internode up to 44 cm. long. *Basal sheaths* up to 6 cm. long, pubescent, ultimately glabrescent, finely striate; the upper sheaths up to 13·5 cm. long, glabrous, smooth, finely striate; ligule scarious, 5–8 mm. long, obtuse; blades up to 19 cm. long, 1–2 mm. wide, flat, linear, long acuminate,

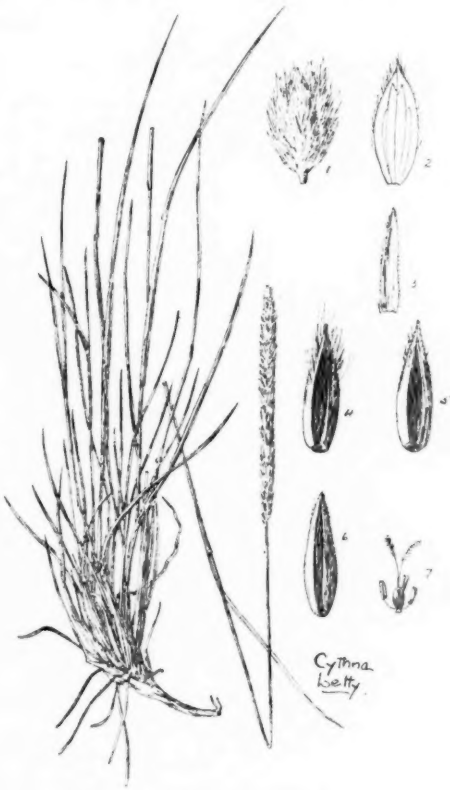


Fig. 4.—*Anthephora argentea* Goossens.
1. Cluster of spikelets. 2. Lower glume. 3. Upper glume. 4. Lower lemma. 5. Upper lemma. 6. Palc. 7. Flower.

acute, glabrous, smooth, finely striate. *Inflorescence* up to 7·5 cm. long, 2–2·5 mm. wide, slender, cylindric, loosely or densely silvery villous. *Rachis* slender, sinuate, angular, glabrous, or often bearded at the nodes; branches reduced to minute cupular stumps. *Clusters of spikelets* up to 8 mm. long, 1·5 mm. wide oblong in outline with the tips of the lower glumes suberect, loosely to densely silvery villous, composed of 5 spikelets. *Spikelets* 1-flowered, up to 7 mm. long. *Glumes* very dissimilar in shape and structure; lower coriaceous, as long as the spikelet, 2 mm. wide, lanceolate to elliptic-lanceolate,

shortly setaceously acuminate, entire or 2-fid, 3–5-nerved with the side-nerves usually percurrent and slightly thickened at the apex or acutely bent inwards and downwards, and more or less joined to the mid-nerve; upper hyaline to thinly membranous, 3–5·25 mm. long, linear to linear-lanceolate, obtuse or acute, sparingly shortly villous on the keel and on the margins, 1–2-nerved. *Lemmas* 2; lower hyaline, sterile, 4–5·5 mm. long, 1–1·5 mm. wide, dorsally compressed, with inflexed margins, oblong or oblong-lanceolate, entire or 2-lobed, often with a short scaberulous mucro, long ciliate in the upper half with more or less spreading simple or bulbous-based hairs up to 2·25 mm. long, 3-nerved; upper subchartaceous, subtending a bisexual or male flower, 4·25–5 mm. long, ·75 mm. wide, lanceolate, acute, glabrous near the base, sparingly villous higher up with short hairs, or only scaberulous, 2–3-nerved. *Pale* of lower lemma absent; of upper similar in texture and shape to its lemma, glabrous or minutely scaberulous at the apex. *Anthers* 2·75 mm. long.

Closely related to *A. pubescens* Nees, but the culms are much more slender and wiry; the ligule is 5–8 mm. long: the inflorescence is much narrower and slender; the lower glumes suberect and not long acuminate.

6. *A. undulatifolia* Hack., in Bull. Herb. Boiss., iv, App. iii, 12; Stapf, in Dyer Fl. Cap. vii, 441; Stapf and Hubbard, in Prain Fl. Trop. Afr., ix, pt. v, 935.
South-West Africa.—Uwuthya, *Barnard* 806 !. Kunene, on river banks, *Barnard* 37 !.

7. *A. Schinzii* Hack., in Abh. Bot. Ver. Prov. Brandenb., xxx, 139; Hack., in Bull. Herb. Boiss., iv, app. iii, 12; Stapf and Hubbard, in Prain Fl. Trop. Afr., ix, pt. v, 942.
South-West Africa.—Amboland, *Schinz* 610 !.

SOUTH AFRICAN MAY-FLIES (*EPHEMEROPTERA*).

By K. H. Barnard, D.Sc., F.L.S.

(With forty-eight Text-figures.)

This paper forms the fourth report on the Fauna of the Mountain Ranges of the Cape Province, for the investigation of which I have received grants from the Royal Society of South Africa and the Research Grant Board. My thanks and acknowledgments are herewith tendered to these bodies.*

Very little work has been done on the South African May-flies. Eaton recorded 4 (described) species. Esben-Petersen, and later Lestage, working on dried material from the South African Museum, part of which was collected by the present author on various mountain expeditions, added 12 species (2 of Lestage's species are synonyms). Not a single nymph has been recorded south of the Zambezi, though Lestage has described some from the Belgian Congo. The present paper brings the total up to 38 species, more than double the number previously known, and contains diagnoses of 6 new genera and 22 new species, and descriptions of the nymphs of 22 species.

The breeding of nymphs in the course of mountain expeditions is almost impossible, and the results recorded in this paper would have been unattainable but for the very opportune and generous help offered by Mr. A. C. Harrison of Cape Town, a member of the Groot Drakenstein Angling Association and the Worcester Trout Anglers Association.

Mr. Harrison, knowing the English May-flies and being interested in the development of fly-fishing in South Africa, applied to me for information. On finding how little was known about South African May-flies he immediately began systematic observations and the breeding of nymphs. The success of his efforts is apparent from the following account, which, so far as the Cape species are concerned, is based almost entirely on the material obtained and bred by him.

A comparatively small amount of material from the South African Museum (adults *in sicco*),† and from my own collecting in the mountains

* Previous reports: 1. "A Study of the Freshwater Crustacea," Trans. Roy. Soc. S. Afr., vol. xiv, 1927. 2. "A Study of the genus Colophon," *ibid.*, vol. xviii, 1929. 3. "The Cape Alder-flies," *ibid.*, vol. xix, 1931.

† Including specimens labelled by Esben-Petersen as types. Ulmer, however (1916, p. 2), says that Esben-Petersen sent him for comparison "die südafrikanischen Typen

(adults and nymphs), has helped in some cases to complete the descriptions of the species and add further localities. I have examined small collections of flies from the Natal and Albany Museums, thanks to the kindness of Dr. Warren and Mr. J. Hewitt.

I have also included the records of the few specimens collected in Ovamboland, South-West Africa, during the course of the Zoological Survey carried out by the South African Museum under the auspices of the South West Africa Administration.

It is difficult adequately to express my indebtedness to Mr. Harrison, but I herewith wish to tender him my best thanks for all the help he has rendered in the preparation of this paper.

Acknowledgments are also due to Mr. F. G. Chaplin of the Jonkershoek Trout Hatcheries, Mr. James Perkins, Hon. Secretary of the Worcester Trout Anglers Association, and Mr. A. T. Packham of Cape Town, for their interest in the investigations. Mr. Packham has frequently motored Mr. Harrison and myself to suitable collecting localities. To Mr. J. C. Dendy of Idas Valley, Stellenbosch, I am indebted for a small but very valuable sample of nymphs from the Transvaal.

As stated above, the works of Eaton, Esben-Peterson, and Lestage contain all that was hitherto known on South African May-flies. With a view to making the present paper a basis for the study of our May-flies, all the known species, including the extra-Cape species, are here incorporated, together with diagnoses of the families and genera.

It is hardly necessary to say how unsatisfactory is the examination of dried material, especially as regards the ♂ genitalia. It is not so much the dried specimen *per se* which has been responsible for several misconceptions in the past, but the omission to relax the specimen, spread out the wings, or mount up the genitalia. Dried specimens are always much darker than in life, and colours based on them are nearly always fallacious. But when moistened and plumped out again they frequently show, if not the true colours, at least the colour pattern. All the material used in this report has been preserved in alcohol, with the exception of that mentioned above; this dried material has been relaxed and examined in fluid in cases where no fresh material was available or where type material seemed to have been inadequately studied. In the field the flies are collected direct into alcohol, but it is always advisable to make a note of any special colours such as yellows or reds, or especially greens, which are often fleeting in alcohol (*cf.* p. 220).

seiner Sammlung." So it would seem that neither Esben-Petersen nor the South African Museum can claim "Holotypes." The types of Lestage's (1924) species have not been returned to the South African Museum, but there are topotypes of all except *Adenophlebia peringueyella* and *Ephemerellina barnardi*.

All the wing tracings have been executed by Mr. Harrison by means of a projector. The other drawings are by the author. Initials after a paragraph or sentence refer only to that paragraph or sentence. In general the majority of the field notes on habits, and all those on habits in captivity, are due to Mr. Harrison.

As regards the breeding of the nymphs, Mr. Harrison has found that even in the case of species inhabiting running water many of them flourish quite well in ordinary tanks, provided some vegetation is put in and the water is changed frequently. Some species, however, are intolerant of still water, e.g. *Tricorythus*, *Castanophlebia*, and Baetids in general. In these cases it is usually a simple procedure to collect fully-grown nymphs with the dark wing-cases, which indicate approaching metamorphosis, and breed these, as they will, as a rule, live a day or two in captivity.

Some of the Leptophlebiids have proved very hardy and easy to rear in captivity, e.g. *Aprionyx*, *Adenophlebia*, and *Choroterpes*. Two instances out of many may be cited : a nymph of *A. peterseni* collected on 27th July 1930 was reared to maturity on 12th November 1930. Several nymphs of *A. tabularis* obtained in midsummer (December–January 1930–31) are still alive at time of writing (31st May 1931) and are nearly mature.

These nymphs have been fed on a blackish or greenish ooze, taken from the lake at Lakeside (Cape Peninsula), which has been found to be a very suitable food supply.

Wing Venation.—The notation proposed by Tillyard (1926—Insects of Australia and New Zealand) is here adopted. In this system the anterior median vein (MA) is accepted as well as the posterior median (M), which has the effect of extending the median area and reducing the anal area as defined by previous authors.

As the Comstock-Needham notation is in use by other authors, it may be useful to quote from Tillyard the most important equivalents in the old and the new notations. The sign + indicates a convex vein and − a concave vein.

(Comstock-Needham)	(Tillyard).
M_1	$= MA_1+$
M_2	$= 1\ MA-$
M_3	$= MA_2+$
Cu_1	$= M_{1+2}-$
—	$= 1\ M+$
Cu_2	$= M_{3+4}-$
$1\ A$	$= Cu_1+$
$2\ A$	$= Cu_2-$
$3\ A$	$= 1\ A+$
$3\ A$	$= 2\ A+$
$3\ A$	$= 3\ A+$

Nomenclature.—As the nymphs of the majority of the Cape species have been discovered, it is not altogether surprising that in some cases the species will not fit in with the generic diagnoses based on material, frequently only adults, from Europe and other parts of the world. The Cape " Atalophlebias " are *Atalophlebia* as adults, but not as nymphs ; and it seems not improbable that the South American " Atalophlebias " will be separated later from the true Australasian *Atalophlebia.*

The genus *Cloeon* has a number of species which agree in wing venation but whose nymphs are sharply divided into two series.

On the other hand, *Baetis bellus* and *Centroptilum excisum,* well differentiated by the wing venation of the flies, approach each other very closely in the character of the mouth-parts of the nymphs. *Adenophlebia peringueyella* and *westermanni* are not distinguishable with certainty as nymphs, but as adults are easily distinguished.

These differences have to be expressed taxonomically, and this explains the introduction of some new generic names.

Colloquial Names.—With a view to standardising the colloquial names of our commonest and most noticeable May-flies, the following list has been drawn up by Mr. Harrison for the benefit of South African Anglers. Spinner is the name given to the imago.

Cloeon lacunosum	Red Border-wing.
Austrocloeon virgiliae	Keurboom Yellow.
Baetis harrisoni	Yellow Dun.
,, *bellus*	Small Pink.
Centroptilum sudafricanum	Small Rusty.
,, *excisum*	Rusty Dun.
Austrocaenis capensis	Cape Cain-fly.
Tricorythus discolor	Worcester Dark Blue.
Aprionyx tabularis	April Dun.
,, *peterseni*	Pied Dun.
,, *intermedius*	Intermediate.
Adenophlebia peringueyella	September Brown.
,, *dislocans*	Summer Brown.
Castanophlebia calida	Chestnut Dun.
Choroterpes nigrescens	Darkening Dun (Bronze Spinner).
Lithogloea harrisoni	Blue-winged Orange (Sherry Spinner),
Afronurus harrisoni, f. *major*	Tawny Yellow.
,, ,, f. *minor*	Dwarf Tawny Yellow.

Economics.—Tillyard (1920, Proc. Linn. Soc. N.S.W., vol. xlv, p. 207) and Phillips (1929) have reported on the value of May-fly nymphs and adults as food for the imported trout. In fact, in many localities in New

Zealand the indigenous May-fly fauna has been noticeably depleted in recent years; one of the reasons stated for this is the destruction by fire or otherwise of the natural vegetation clothing the banks of the rivers, thus reducing the amount of plankton (denuded river-banks increase scouring) and shelter for the flying stages. Consequently the Angling Associations in South Africa and the owners of properties with fishing rights will do well to consider this aspect of the evils of veld-burning, and add their weight in the scale against a practice which for many other reasons cannot be too strongly deprecated.

Phillips states that in New Zealand about 10 per cent. of the trout-food is composed of May-flies. For South Africa there are as yet no data. At certain seasons, however, May-flies and their nymphs must form very nearly the bulk of the trout's food. I have had trout stomachs submitted to me which were literally stuffed with nothing else but Baetid nymphs (*e.g.* from the Eerste River in October). Mr Harrison informs me that he has found the nymphs of the Tawny Yellow to be numerous in stomachs of trout caught at midsummer and in very low water; and under such conditions he has found that trout readily accept a wingless imitation " fly " tied to represent one of these nymphs.

This is a matter of special interest to anglers, most of whom look upon low-water conditions as hopeless. The remedy is to use artificial nymphs.

Characteristics of the South African May-fly Fauna.—It is obviously premature to discuss in detail the composition of the May-fly fauna of South Africa, as such a very small area has been systematically explored. With the exception of the south-west corner of the Cape Province, the records from other parts are, in truth, merely the results of casual collecting, often by persons not fully cognisant of these particular insects or their habits.

One or two general remarks, nevertheless, may be permitted, because, even with the meagre data at our disposal, there appears to be a very real and obvious difference in the May-fly fauna of the Cape and that of Natal.

Large and conspicuous forms like *Polymitarcys*, *Eatonica*, and *Elassoneuria* are not known from the South West Cape. It may be stated with fair certainty that they do not occur here. They represent a tropical element which extends from Central Africa south-eastwards to Natal and possibly to the Eastern Province. In the Transvaal also, at least in the eastern and northern parts, they will almost certainly be found to occur, as well as in Rhodesia.

Both these regions are an untouched field as regards May-flies. From the small collection of nymphs made by Mr. Dendy it is possible to state that the genera *Eatonica* (subimago), *Austrocloeon*, *Centroptilum*, *Adeno-*

phlebia, *Castanophlebia*, and *Euthraulus* occur in the Transvaal. *Aprionyx*, *Adenophlebia*, *Centroptilum*, *Cloeon*, and *Afronurus* are known to extend to Natal (including Zululand). In Rhodesia only *Eatonica* and *Cloeon* are recorded. In Ovamboland the genera *Eatonica*, *Cloeon*, *Pseudocloeon*, *Centroptilum*, *Centroptiloides*, and *Afronurus* have been collected.

Tricorythus occurs from Egypt to South Africa ; it is known from one locality in the Orange Free State, from Zululand, and probably occurs also in the Transvaal. It appears to be absent in the extreme South West Cape, *i.e.* west, south-west, and south of Tulbagh and Worcester in the valleys of the Little Berg and Breede Rivers respectively. Mr. Harrison has not found its peculiar and distinctive nymph in either the Berg River or Eerste River systems, or in the Holsloot (Louwshoek) and Smaalblaar (Du Toits Kloof), which are tributaries of the Breede River, but arising in the mountain massif (Wellington-Slanghoek-Goudini) to the south.

Physiographically the river at Tulbagh belongs to the Breede River system, as prior to its capture by the Little Berg River cutting through Tulbagh Poort (see map in the second of these reports : Trans. Roy. Soc. S.A., vol. xviii, pl. 1) it formed the head-waters of the Breede River. The presence of *Tricorythus*, therefore, at Tulbagh is not surprising. But its absence in the tributaries flowing into the Breede River *from the south* is surprising, and at present inexplicable. Perhaps, when we know more about its distribution and the factors governing its existence, it may prove to be an interesting if not important item of evidence in the history of the Cape mountains. At present it is the only one of the Cape May-flies which indicates possibilities in this direction.

Perhaps the chief feature of the May-fly fauna of the South West Cape is the abundance of Leptophlebiids and the presence of two representatives of the *Ephemerellidae*.

Apart from such low-lying localities as Lakeside and the pond in the Worcester Memorial Park, and also the actual ponds in the Jonkershoek Trout Hatcheries, in which the water is still or only feebly flowing, all the localities examined by Mr. Harrison and myself are typical swift-running mountain streams. In the case of Michell's Pass (Ceres to Wolseley), Hex River Poort, and Tradouw Pass, it would be more correct to say rivers. During the winter months (April or May to September and October) they are all liable to sudden and considerable spates.

To be correlated with this liability to severe floods is probably the fact that in these rivers and streams the large smooth-clawed Leptophlebiid (*A. tabularis*) nymphs are absent, whereas specially adapted forms like *Tricorythus*, *Afronurus*, *Lithogloea*, and even *Adenophlebia*, which is comparatively unspecialised but has denticulate claws, are abundant. In the

larger pools, however, *A. tabularis* grows very rapidly in late summer when the rivers are low and vegetable detritus tends to accumulate.

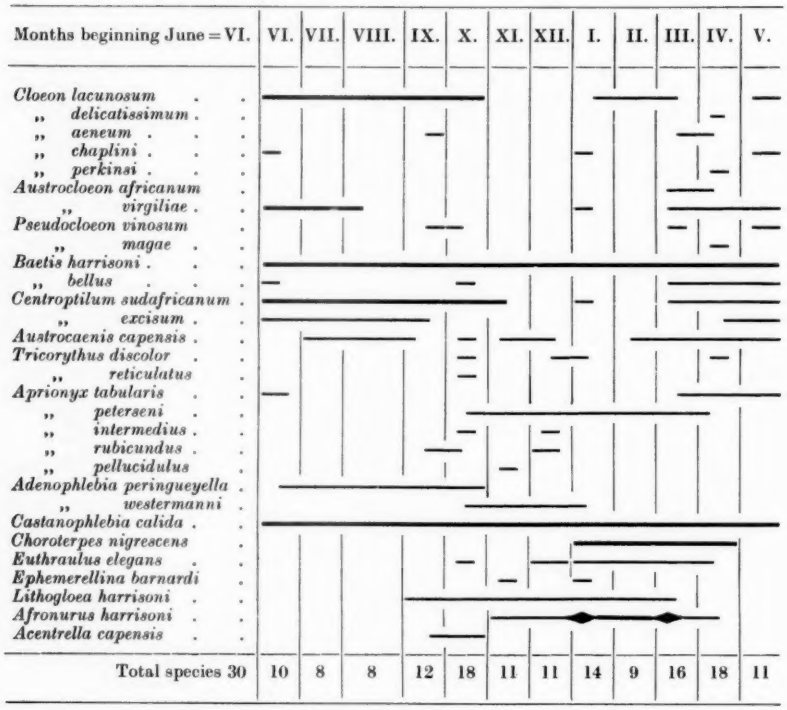
Characteristic of the smaller waterfalls and chutes in the smaller streams are Baetids (*B. harrisoni* and *Centroptilum sudafricanum*) and *Castanophlebia.*

Seasonal Occurrence.—As records are so few and so little intensive collecting has been done in any region except the South West Cape, it is no use discussing the seasonal appearance of the flies except in this region. The data derived from Mr. Jones's Zululand collecting, however, may be mentioned, as this was continued throughout the year over a number of years: *Polymitarcys*, February; *Eatonica*, December; *Elassoneuria*, February to April; *Austrocloeon africanum*, September and December; *Centroptiloides*, September, December, February, March, April; *Tricorythus discolor*, October; *Afronurus peringueyi*, September, October, December, February, March, April. All these records lie within the period of summer rainfall; and there appears to be a gap from April to September when Mr. Jones obtained no May-flies. These records are of the larger and more conspicuous species, and it is probable that the gap is a reality. On the other hand it is almost certain that with further collecting some species, especially the smaller inconspicuous species, will be found at all seasons of the year.

Experience has shown that in the South West Cape there is not a month in which May-flies of one species or another may not be found. At first it did seem that certain species appeared at definite seasons; but in the case of the more abundant species continued observations have proved the extension of what was considered the " season " by several weeks or a month or two. In certain cases it now seems that the flies emerge throughout the year in a succession of broods.

The emergence of some species may be continuous and their abundance nearly uniform (e.g. *Castanophlebia*), though there may be a " peak " or maximum (e.g. *Afronurus*). Other species (e.g. *Austrocaenis* and *Tricorythus*) emerge in large swarms at intervals.

The following chart indicates the seasonal occurrence of 30 Cape species. It is only a preliminary conspectus, and many of the gaps in it will be filled up by future observations. But it shows that there is a greater abundance of flies during the summer and especially the autumn months (October to April), a period which in the Cape coincides with the period of least rainfall. A noteworthy contrast with what appears to be the case in Natal. It must, however, be borne in mind that as a rule more collecting is done during the summer than the winter months. In the case of *Afronurus harrisoni* the times of maximum abundance of the two forms are shown, f. *major* at New Year, f. *minor* in February–March.


Months beginning June = VI.
VI. VII. VIII. IX. X. XI. XII. I. II. III. IV. V.
Cloeon lacunosum
„ delicatissimum
„ aeneum
„ chaplini
„ perkinsi
Austrocloeon africanum
„ virgiliae
Pseudocloeon vinosum
„ magae
Baetis harrisoni
„ bellus
Centroptilum sudafricanum
„ excisum
Austrocaenis capensis
Tricorythus discolor
„ reticulatus
Aprionyx tabularis
„ peterseni
„ intermedius
„ rubicundus
„ pellucidulus
Adenophlebia peringueyella
„ westermanni
Castanophlebia calida
Choroterpes nigrescens
Euthraulus elegans
Ephemerellina barnardi
Lithogloea harrisoni
Afronurus harrisoni
Acentrella capensis
Total species 30
10 8 8 12 18 11 11 14 9 16 18 11

Key to the Suborders (Ulmer, 1920).

1. In ore-wing M_{1+2} and Cu_1 strongly divergent from base. Hind tarsus with only four (or fewer) freely movable joints (5th joint, if indicated, immovably fused with tibia) . . . . . *Ephemeroidea.*
2. In fore-wing M_{1+2} and Cu_1 parallel at base, or only slightly divergent.
   a. Hind tarsus with four freely movable joints (5th joint, if indicated, fused with tibia) . *Baetoidea.*
   b. Hind tarsus with five movable joints . . . . . *Heptagenioidea.*

Suborder EPHEMEROIDEA.

Key to the South African Families (after Ulmer).

1. Wings milky. No disconnected intercalaries on hind margins. Legs weak, hind legs short and feeble *Polymitarcidae.*
2. Wings clear. Numerous short disconnected intercalaries on hind margins, especially in hind-wing. Legs strong *Ephemeridae.*

Family Polymitarcidae.

Ulmer, 1920, p. 102.

Only one genus in South Africa.

Gen. *Polymitarcys* Eaton.

Eaton, 1883, p. 43, and pl. xxviii (nymph); Ulmer, 1920, p. 107; Lestage, 1921, p. 188, fig. 47 (nymph).

In fore-wing the fork of MA is distal to the fork of RS. Two or more intercalaries proximal to Cu_1, connected by cross-veins, and converging basally. Genital styles in ♂ 4-jointed; penis bilobed. Cerci in ♂ 2, very long, in ♀ 3, shorter.

Nymph narrow, cylindrical. Eyes lateral; antennae longer than head; mandibles robust, elongate, projecting like forceps in front; labial and maxillary palps 2-jointed. Legs rather short, front pair stout. First gill minute, simple; 2nd–7th gills bifurcate, folded dorsally over abdomen, margins serrate. Cerci 3.

Habits.—The nymphs burrow in the mud of slowly running rivers and streams.

Polymitarcys savignyi (Pict.).

Eaton, 1883, p. 46, pl. vi, fig. 10*b* (a S. African sp.); Esben-Petersen, 1913, p. 178 (*capensis*); Navas, 1915, p. 172, fig. 1 (*temerata*); Lestage, 1918, p. 76, fig. 1 (egg-mass); Ulmer, 1920, p. 107; Lestage, 1924A, p. 319.

The nymph of this species has not yet been found in South Africa.

Localities (adult).—Zululand (S.A.Mus.); Pietermaritzburg, Natal (Warren. Nat. Mus.).

Distribution.—Egypt; Cameroons; Togo; Belgian Congo; Zambezi.

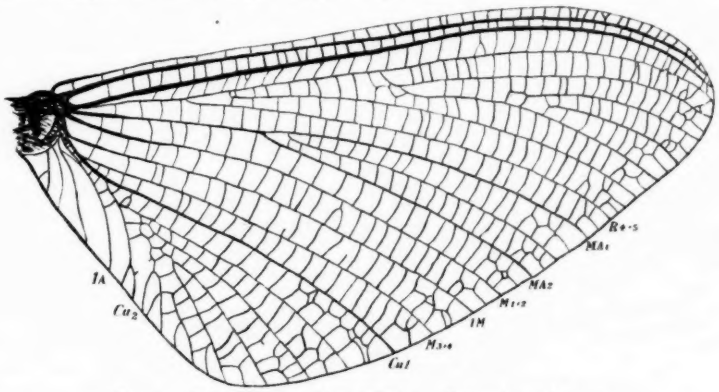


Fig. 1.—*Polymitarcys savignyi* (Pict.). Fore-wing ♀ imago.

Family Ephemeridae.

Ulmer, 1920, p. 107.

Key to the South African Genera.

1. Cerci 3, well developed, subequal, in both sexes. Genital styles of ♂ 4-jointed. Prothorax of ♀ broader than long *Ephemera.*
2. Cerci 2 in ♂, 3 in ♀. Genital styles of ♂ 3-jointed. Prothorax of ♀ longer than broad. . . *Eatonica.*

Gen. *Ephemera* Linn.

Eaton, 1883, p. 58; Ulmer, 1920, p. 109; Lestage, 1921, p. 182 (nymph).

Fore leg of ♂ about ⅘ length of body, tarsus about 1½ times as long as tibia and about 4 times as long as femur; in ♀ tarsus subequal to tibia. Genital styles of ♂ 4-jointed, the 2nd joint longest, 3rd and 4th short; penis bilobed. Cerci 3 in both sexes, well developed, subequal. Prothorax of ♀ broader than long.

Nymph burrowing in mud. Head with 2 more or less prominent projections in front. Mandibles with long subulate tusks. Legs strong. Cerci 3. Gills 7 pairs, all narrow, bilobed, the 1st pair small, simple, the others with the margins strongly fringed.

Remarks.—The occurrence of this genus in Africa rests on some fragmentary specimens recorded by Eaton (1913) from Nyasaland and Uganda. The species described below constitutes therefore the first definite record of this genus in Africa.

Ephemera natalensis n. sp.

Imago.—♂. 10th sternite in ♂ distally excised, the lateral portions forming bases for the styles; penis apically bilobed, the lobes narrow and widely divergent, a pair of sharply pointed processes (Eaton: stimuli) on ventral surface.

Eyes black (*in sicco*). Thorax and abdomen warm castaneous brown; the abdominal segments dorsally marked with a dark stripe near the lateral margins, more conspicuous on the posterior than the anterior segments. Legs

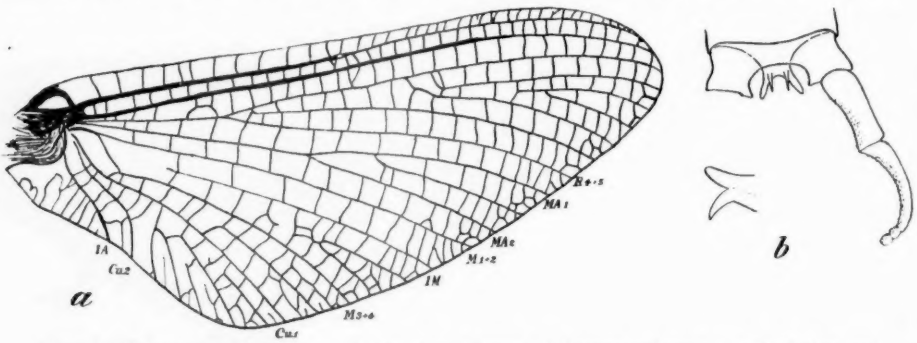


FIG. 2.—*Ephemera natalensis* n. sp. *a*, fore-wing ♂ imago; *b*, forceps and penis ♂, ventral view, and lateral view of penis.

fulvous. Cerci fulvous, narrowly annulated. Wings faintly tinged with brown, with an inconspicuous spot at the fork of MA, and the margin of hind-wing slightly darker; neuration fulvous brown, Sc and R dark brown, cross-veins slightly thickened with brown suffusion.

Body 13–14 mm., wing 12–12·5 mm., cerci about 20 mm.

Locality.—Pietermaritzburg, Natal (Akerman, 1916, Natal Mus.).

Remarks.—I am indebted to Dr. Warren, Director of the Natal Museum, for submitting the two ♂♂ on which this species is instituted. In coloration it resembles the European *vulgata*, as far as can be judged *in sicco*, but is distinguished by the penis.

Gen. *Eatonica* Navas.

Navas, 1912 (Tr. 2 Entom. Congr.), pp. 180. 181; Ulmer, 1920, p. 109; Lestage, 1923A, p. 304.

Fore leg of ♂ ⅘–¾ as long as body, tarsus about 1¾ as long as tibia, in ♀ subequal to tibia. Genital styles ♂ 3-jointed; penis bilobed. Cerci 2 in ♂, 3 in ♀; in the ♀ the median one is shorter and more slender than the lateral ones. Prothorax of ♀ longer than broad.

The nymph is unknown, but may be expected to resemble that of *Ephemera* (Eaton, 1884, pl. xxx; Lestage, 1921, fig. 45) in general; that is, it is a mud-burrower, with projecting tusk-like mandibles.

Eatonica schoutedeni (Navas).

Navas, 1911 (Ann. Soc. Sc. Bruxelles, 1910), p. 222, fig. 3; Esben-Petersen, 1913, p. 179 (*Hexagenia fulva*); Eaton, 1913, p. 276, fig. (*Hexagenia illustris*); Navas, 1915 (Mem. R. Ac. Ci. Barcel., xi.), p. 373 (*nimia*); Lestage, 1918, p. 82, figs. 2, 3; Needham, 1920, p. 38, pl. v, figs. 1, 2 (*Pentagenia s.*); Lestage, 1923A, p. 304, and 1924A, p. 320.

Imago.—A dark band on either side of pro- and meso-thorax, and characteristic dark marks dorso-laterally on the pale whitish abdominal segments.

Remarks.—The type of *H. fulva* E. P. ♀ has the stumps of 3 cerci clearly visible. The Wankie ♀ also has 3 stumps, and the Durban ♀ still retains the 3 cerci intact. A ♂ from South West Africa has a minute rudiment of the median cercus (*cf.* Eaton's figure), as has also the ♂ imago from Pietermaritzburg. The ♀ from Wankie is very small: body 12 mm., wing 14 mm., thus being even smaller than Navas' *nimia*.

Localities.—Zululand; Durban (S.A. Mus.); Wankie, S. Rhodesia (S.A. Mus.); Sabi, Transvaal (S.A. Mus.); Andoni, Ovamboland, S.W.A. (Jan. 1921, K.H.B.); Pietermaritzburg (Natal Mus.).

Distribution.—Belgian Congo; French Congo; Cameroons; Togo; Uganda; Tanganyika; Abyssinia.

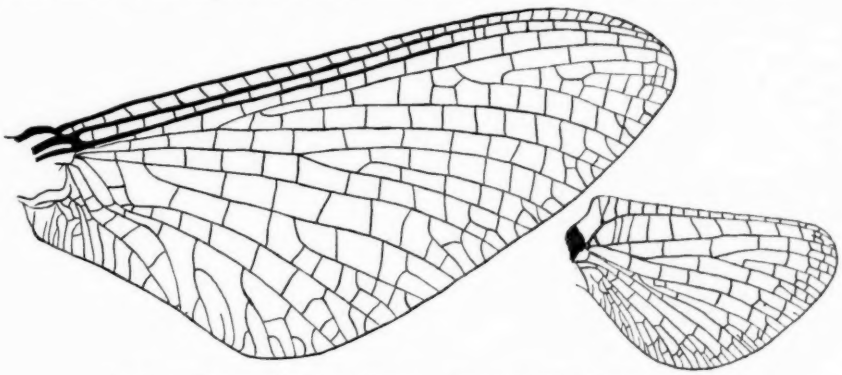


FIG. 3.—*Eatonica schoutedeni* (Navas). Fore- and hind-wings ♀ imago.

SUBORDER BAETOIDEA.

Key to the South African Families (after Ulmer).

I. In fore-wing Sc united with R. Wings milky or cloudy, with very few veins . . . *Oligoneuriidae.*

II. In fore-wing Sc distinct from R.

A. In fore-wing MA not forked. Usually few cross-veins. Hind-wings very small or absent . *Bartidae.*

B. In fore-wing MA forked.

1. Fore-wings cloudy, ciliate on hind margin, no disconnected intercalaries, cross-veins few. Hind-wings absent . . . . . *Brachycercidae.*

2. Fore-wings clear, with numerous cross-veins. Hind-wings present.*

a. In fore-wing Cu_2 nearer to 1A than to Cu_1 at base. No disconnected intercalaries between M_{3+4} and Cu_1. Genital styles of ♂ with 2 short terminal joints . . *Leptophlebiidae.*

b. In fore-wing Cu_2 nearer to Cu_1 than to 1A at base. Several, usually 2, disconnected intercalaries between M_{3+4} and Cu_1. Genital styles ♂ with one short terminal joint . *Ephemerellidae.*

Family OLIGONEURIIDAE.

Ulmer, 1920, p. 127.

Wings milky or cloudy. In fore-wing Sc united with R. Very few longitudinal veins (4–7). In hind-wing cross-veins absent, or a few in basal part.

Only one genus in South Africa.

Gen. *Elassoneuria* Eaton.

Eaton, 1883, p. 32; Ulmer, 1920, p. 129; Lestage, 1916, p. 314, figs. 1–5, and 1917, p. 122, fig. 1 (nymph).

In fore-wing between R and Cu two strong longitudinal veins, of which the first arises at base of wing, the second from the first shortly before middle of wing. Between this second vein and Cu a long indistinct vein which arises from the first vein. Numerous very indistinct cross-veins. Cu forked. Genital styles of ♂ 3-jointed, 1st joint very long; penis bilobed. Cerci 3.

Nymph in general resembling that of *Oligoneuria* (Eaton, pl. xxvi; Lestage, 1921, fig. 54). Flattened, head more or less rounded, eyes dorsal. Antennae short. Mandibles short, not visible from above. Upper lip transverse, entire, setose. Maxilla with a bunch of branched gills at base. Femora stout, tibiae and tarsi rather slender; femur and tibia of fore leg with long plumose hairs. Gills double, consisting of a lamella and a bunch of branched fibrillae; 1st gill inserted ventrally, lamella very small; 2nd–7th gills inserted dorsally, the lamella considerably larger than, and covering, the bunch of fibrillae. Cerci 3, not longer than abdomen.

By analogy with the European *Oligoneuria* this nymph should be sought for under stones in slowly flowing rivers.

The following brief explanation of the simplified neuration of the fore-wing may be given. The simplification is only apparent, and the key to the explanation is found in the position of Sc. Although the subcosta is stated to be united with R, it is not really so. It is a concave vein, and lies in the groove formed by the approximation of R to C by folding of the membrane. This fold is quite appreciable and it obliterates the pterostigmal area with its distinct cross-veins; consequently in the dried wing C and R appear to run into one another. Eaton's figure (pl. iii, fig. 3) is evidently taken from a dried wing, and gives no hint of the true venation.

* Absent in *Hagenulodes* and *Hagenulopsis* (*Leptophlebiidae*).

When a wing is relaxed in hot water and examined in fluid the true relationships of the veins can be traced. The folding of the membrane, causing Sc to underlie R_1, occurs also in connection with the other large veins. The concave vein R_2 lies close up against the posterior side of R_1. The peculiar kinks in the cross-veins running apparently from R_1, but in reality from R_2, seem to indicate the course of the suppressed vein R_2.

Examination of the big forked vein also shows folding of the membrane causing the concave veins R_{4+5} and M_{1+2} to underlie the convex MA. The intercalaries of Rs, MA, and M are entirely suppressed. M_{3+4}, however, is still traceable as a very faint vein arising proximally from M (not from the base of MA) and distally branching into an extremely fine reticulation.

The same approximation of veins occurs in connection with Cu and A. The fork of Cu is distinct, and close under Cu_1 lies I Cu. 1A is approximate to Cu_2.

Thus throughout the wing the membrane has been pleated near the convex veins, and the chief concave veins come to underlie the former, while the intercalaries (except I Cu) have been suppressed.

An examination of the wing-cases of the nymph would prove most interesting, and also the comparison of properly prepared wings of the other Oligoneuriid genera with that of *Elassoneuria*.

It is curious to see that an approximation of the concave veins to the convex veins, at least distally, has taken place in the genera *Anagenesia* and *Plethogenesia* belonging to the preceding suborder *Ephemeroidea*. This approximation leads to a division of the wing into broad areas in which the cross-veins tend to disappear, and a somewhat scalloped wing margin (Eaton, pls. i and ii, "Palingenia").

The whole anal-cubital margin of the fore-wing of *Elassoneuria* can be linked with the costal margin of the hind-wing, and the two together form a wing of considerable expanse.

Elassoneuria trimeniana (M'Lach.).

Eaton, 1883, p. 32, pl. iii, fig. 3; Navas, 1911 (Ann. Soc. Sci. Brux.), p. 221, fig. 2 (*congolana*); Eaton, 1913, p. 272, fig. 1 (*candida*); Esben-Petersen, 1913, p. 177; Lestage, *loc. cit. supra* (nymph); Lestage, 1924A, p. 346; Navas, 1926 (Broteria, xxiii), p. 102, and 1930 (*ibid.*, xxvi), p. 16.

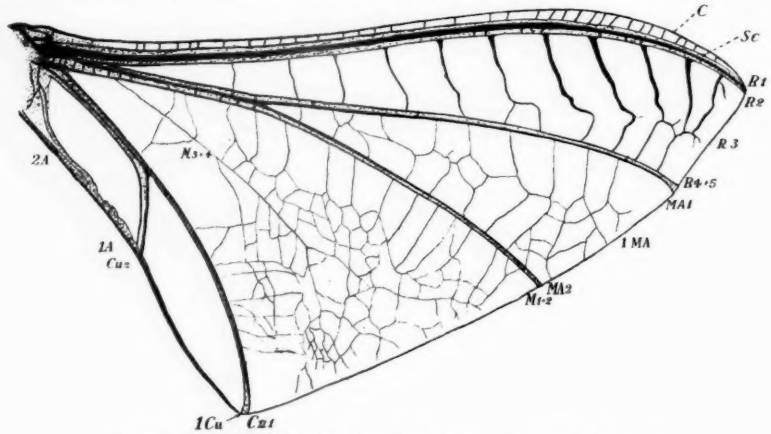


FIG. 4.—*Elassoneuria trimeniana* (M'Lach.). Fore-wing ♀ imago.

One of the Natal Museum specimens had a large irregular pale-green egg-mass attached to it. When placed in water the green colour faded to yellow, and the eggs separated. They are broadly oval or subrotund, ·4–·5 mm. long diameter, surface feebly reticulated, without attachment threads. A small mass of eggs attached to one of the South African Museum specimens is orange in colour.

Localities.—Umvoti, Natal (at light, March 1867); M'fongosi, Zululand (February, March, and April, S.A. Mus.); Pietermaritzburg (at light, April 1931, Natal Museum).

Distribution.—Belgian Congo; French Congo; Cameroons; Southern Nigeria; Madagascar. The nymph has been recorded from the Belgian Congo.

Family BAETIDAE.

Ulmer, 1920, p. 123.

Imago.—Subcosta well developed, distinct. MA and M simple, MA_2 and M_{3+4} disconnected. Cross-veins usually few. Hind-wings absent, or if present very small and (usually) narrow, with 1–3 veins and a few cross-veins. Wings hyaline. Eyes turbinate in ♂.

Nymph.—Swimming type. Head more or less bent downwards. Labium with lobes longer than broad, palp 2–3 jointed. Maxillary palp 2–3 jointed. Cerci 2–3, strongly ciliate. Gills 7 pairs (occasionally only 6), lamellate, single or double.

Key to the South African Genera.

Imagos.

1. Hind-wings absent.
   - *a.* Marginal intercalaries single . . . . . *Cloeon.* / *Austrocloeon.*
   - *b.* Marginal intercalaries paired . . . . . *Pseudocloeon.*
2. Hind-wings present.
   - *a.* Marginal intercalaries paired. 1A forked . . . . . *Baetis.* / *Acentrella.*
   - *b.* Marginal intercalaries single. 1A simple.
     - i. Hind-wing very long and narrow, with acute process on costa, at most 2 veins, no cross-veins *Centroptilum.*
     - ii. Hind-wing rather broad, with double costal process, 3 veins, the middle one forked . *Centroptiloides.*

Nymphs.

A. 3 cerci. (Nymph of *Centroptiloides* unknown.)
1. 7 pairs of gills.
   - *a.* 2nd–5th gills always double.
     - i. Maxillary palp 3-jointed . . . . . *Cloeon.*
     - ii. Maxillary palp 2-jointed . . . . . *Austrocloeon.*
   - *b.* All gills single . . . . . *Centroptilum excisum* and *Baetis.*
2. 6 pairs of gills . . . . . *Pseudocloeon* and *Centroptilum sudafricanum.*

B. 2 cerci . . . . . *Acentrella.*

Gen. *Cloeon* Leach.

Eaton, 1885, p. 179; Ulmer, 1920, p. 125; Lestage, 1921, p. 248 (nymph); Lestage, 1923, p. 192, and 1924b, p. 426.

Imago.—Hind-wings absent. Marginal intercalaries single. First cross-vein between R_1 and R_2 meets latter distinctly proximal to the first cross-vein between R_2 and $1R_2$. Cross-veins mostly in three dislocated series. Cross-veins connecting Sc–R_1–R_2–$1R_2$ distally present or absent. Genital styles of ♂ 4-jointed, 3rd joint longest, 4th minute. Front tarsus of ♂ longer than tibia. Claws dissimilar in all legs in both sexes. Cerci 2.

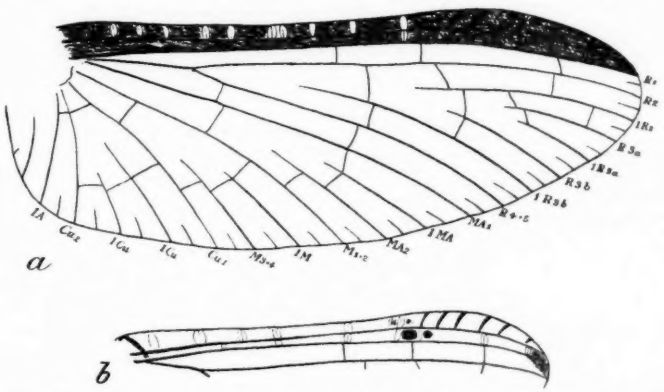


FIG. 5.—*Cloeon*. *a*, *lacunosum* n. sp., fore-wing ♀ imago; *b*, *rhodesiae* n. sp., marginal area of fore-wing ♀ imago.

Nymph.—Eyes lateral. Antennae elongate. Mandibles without prostheca. Maxillary palp 3-jointed (2-jointed in one European species). Inner lobes of labium shorter, but not much narrower than outer lobes. Median lobe of hypopharynx without lateral processes; lateral lobes (paragnaths) not curving outwards. Gills, 1st–6th pairs typically double, 7th single.

Remarks.—It is said that the eggs are not deposited in the water immediately after mating, as in other May-flies. The ♀ retires to a secluded retreat and remains there for a week or more, during which time the embryos have reached a certain stage; she then leaves her retreat and flies over the water, eventually coming to rest on the surface with outspread wings, when the eggs are laid. When the egg touches the water the larvules break through the shell and swim away (see Lestage, 1921, p. 249).

In connection with this question, it may be mentioned that a ♀ of *A. virgiliae* from the Clovelly locality (p. 220) emerged from the nymph on 29th June (imago, 30 hours later) and lived until 7th August, *i.e.* 40 days. Three ♂♂ were put into her cage, one by one, but no mating was observed. The average life of each ♂ was 14 days. It is probable that mating occurs only during flight. The body of this ♀ was examined after death and found to contain a comparatively small number of eggs, all of which were unfertilised. The longevity of this ♀ seems to suggest ovoviviparity, as in the case of *C. dipterum*. Cf. literature quoted by Lestage, 1921, p. 250.

Eaton first recorded this genus from South Africa (Trans. Entom. Soc., 1871, p. 103, and Monograph, p. 186). Esben-Petersen has described a species from South Africa, and Lestage has added two from the neighbouring region of the Congo. Seven further species are here described together with the nymphs of three of them.

The adults of all these species show the typical venation of *Cloeon*, as opposed to that of *Procloeon*, in which latter genus the 1st cross-vein between R_1 and R_2 meets the latter opposite to or distal to the cross-vein between R_2 and $1R_2$.

The nymphs, on the other hand, diverge from the typical *Cloeon* nymph (*cf.* Eaton, 1885, pl. xlvii, and Lestage 1921, fig. 66) in the composition of the gills and the maxillary palp.

As regards the gills, typical *Cloeon* has the 1st–6th pairs double, the 7th single; *lacunosum* n. sp. has the 1st and 7th single, the others double; *africanum* and *virgiliae* n. sp. have the 1st–5th pairs double, the 6th and 7th single. There might be a possibility of splitting up the genus *Cloeon* on this character of the gills, but for the fact that in several European species a certain amount of variation occurs in the proportional size of the two lamellae composing each double gill (*cf.* Lestage, 1921, key to species, p. 252); and although the five European species agree in the typical gill formula (1st–6th double, 7th single) it is no great jump from the reduction of the inner lamella to its complete suppression.

There is, however, the character of the maxillary palp. This is typically 3-jointed, but in *praetextum* it is only 2-jointed (Lestage, 1921, p. 252). In the allied genus *Procloeon* it is also 2-jointed and slender, especially the long 2nd joint.

In the South African nymphs, while no great importance can be attached to the differences in the gill formula, we find that two species possess the slender 2-jointed maxillary palp of *Procloeon*. It may be noted that they possess also the marked clavate apex of the labial palp found in *Procloeon*. Associated with these features, however, the adult possesses the typical venation of *Cloeon*. Therefore either *Procloeon* is not justified, or the institution of another genus for the two South African species *africanum* and *virgiliae* is required.

The latter course is adopted, though at the present moment it leads to the inconvenience of assigning five species to *Cloeon*. The future discovery of their nymphs will show to which genus they should really be assigned.

Eaton's record of a species of *Cloeon* from Knysna may possibly refer to either *africanum* or *virgiliae*.

Key to the South African Species.

1. 4 cross-veins before bulla.
   - *a*. Marginal area in ♀ deep amber, with clear, window-like spots . . . . *lacunosum*.
   - *b*. Marginal area pale yellow, two dark spots in subcostal area below pterostigma . . *rhodesiae*.
2. No cross-veins before bulla.
   - *a*. Cross-veins faint or very faint.
     - i. 2–3 incomplete cross-veins in pterostigmal area. Wing ♀ 3·25 mm. . . *delicatissimum*.
     - ii. Several, some incomplete, cross-veins in pterostigmal area. Wing ♀ 5·5 mm. . . *aeneum*.
     - iii. 6–8 complete, some forked, cross-veins in pterostigmal area. Wing ♀ 9 mm. . . *chaplini*.
   - *b*. Cross-veins well marked, opaque, whitish or yellowish. 4 cross-veins in pterostigmal area . *perkinsi*.

Cloeon lacunosum n. sp.

Imago.—In the costal area 4–6 extremely faint cross-veins before bulla, 6–8 beyond bulla, those in the pterostigmal area oblique, complete; in subcostal area 2–4 cross-veins. Cross-veins in distal part of wing connecting $Sc–R_1–R_2–1R_2$ present.

Body ♂ 5 mm., ♀ 6–7 mm.; wing ♂,5 mm., ♀ 6–7·5 mm.; cerci ♀ 9 mm.

Head white, with two brown submedian longitudinal narrow streaks in ♀. Eyes pale French-grey, with two horizontal (in lateral view) dark stripes, in ♂ lower eyes as in ♀, turbinate eyes pinkish-orange. 1st, 3rd, and ventral part of 2nd joint of antenna white, dorsal part of 2nd joint brown, remaining joints brown. Prothorax white, with mediodorsal and submedian brown longitudinal stripes. Meso- and meta-thorax straw or pale amber-coloured, the sutures mostly marked in brown, a medio-dorsal dark line flanked on either side by a white streak; laterally white, appearing in some cases almost silvery. Abdomen brown, darkest medio-dorsally, but somewhat mottled or speckled, dorso-laterally pale grey-brown, with a short dark streak on each segment; ventro-laterally pale grey or almost white, with a black speck on each segment; medio-ventrally pale brown, somewhat speckled. In ♂ thorax and abdomen as in ♀, but prothorax brown, meso-thorax darker, the lateral portions not so pale. Legs fulvous in ♀, pale straw in ♂, femora with faint darker longitudinal stripes. Cerci white, with narrow dark annulations. Genital styles of ♂ white. Wings hyaline, quite clear in ♂, but C, Sc, and R pale yellow; in ♀ costal and subcostal areas pale castaneous or fulvous, with a series (5–10) of hyaline, window-like, linear or narrow-oval spots, mostly extending between C and Sc, but sometimes developed only on C. Cross-veins faintly visible in these spots. Pterostigmal cross-veins and the 3 cross-veins in radial area (especially the 2 proximal ones of the latter) whitish.

Subimago.—Similar, with the castaneous marginal coloration in ♀, but the hyaline spots not, or very faintly, developed.

Nymph.—Abdominal segments 1–9 minutely denticulate dorsally and ventrally on posterior margins, the denticles confined to the median portion anteriorly, but extending to the lateral margins posteriorly, and on to the

lateral margins from the 5th or 6th segment onwards. Mouth-parts as figured. Legs moderately slender, femora with short simple spines, tibiae and tarsi with longer and more densely set simple spines; claws finely pectinate. First gill with only a single lamella, the outer margins of the 7th and of the lower lamellae of 2nd–6th gills with a few setae.

Up to 7·5 mm.; cerci 3 mm.

In life semitransparent, white, greenish or yellowish, the wing-cases of full-grown nymphs ready for edysis castaneous. Eyes black, ocelli greyish. Abdomen in full-grown nymphs showing the same colour pattern as the adult. Cerci pale, with dark annulations not corresponding with the segmentation.

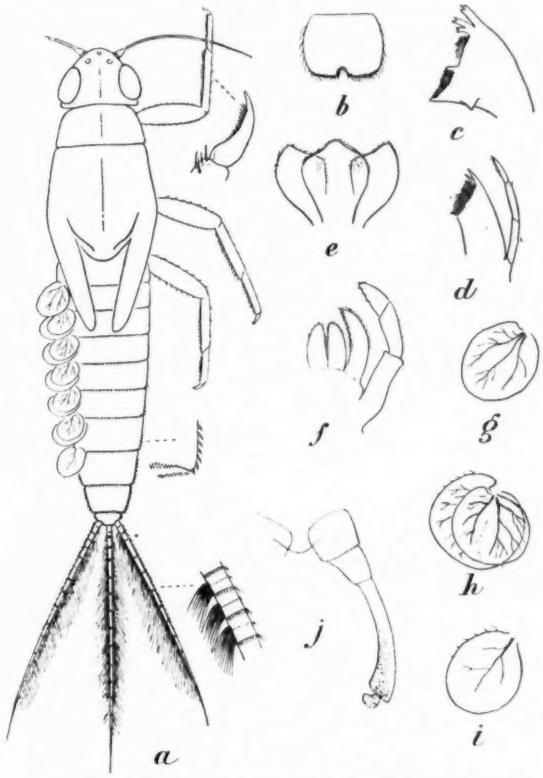


FIG. 6.—*Cloeon lacunosum* n. sp. *a*, nymph, with claw, abdominal segment, and portion of lateral cercus further enlarged; *b*, labrum; *c*, mandible; *d*, maxilla; *e*, hypopharynx; *f*, labium; *g*, *h*, *i*, 1st, 3rd, and 7th gills respectively; *j*, forceps of ♂ imago.

Localities.—Lakeside and Kalk Bay, Cape Peninsula (A. C. H.); Table Mt. (March 1920 and January 1928, K. H. B.); Rondebosch, Cape Peninsula (A. T. Packham); Jonkershoek, Stellenbosch (May 1931, A. C. H. and K. H. B.); Potteberg, Bradasdorp Div. (A. T. Packham).

Remarks.—Closely allied to *C. dipterum*, but differing in the coloration of imago and the castaneous costal margin of subimago and in the single first gill of nymph.

Habits.—This species inhabits still waters, or slowly flowing streams; it is abundant at Lakeside, and occurs also at Clovelly, Kalk Bay; and in the ponds at the Jonkershoek Trout Hatchery. Subimagos and imagos have been found in the months of January to March, May, June to August.

The nymphs in all stages can be found at nearly all seasons, and the species seems to go on throughout the year in a succession of hatches. The nymphs closely match the algae among which they live; the first 6 pairs of gills are in constant motion, but the 7th pair is held out rigidly at right angles to the body.

Cloeon rhodesiae n. sp.

Imago.—♀. 4 cross-veins before bulla, 6–7 in pterostigmal area, simple, oblique, thickened. 6–7 subcostal cross-veins. Cross-veins connecting Sc–R_1–R_2–$1R_2$ distally present.

Body 6 mm.; wing 6·5 mm.; cerci 14 mm.

Head, thorax, and abdomen pale ochraceous or yellow. Abdominal segments with a medio-dorsally raw-sienna stripe, which in some segments is triangular, narrow anteriorly, widening posteriorly; a triangular castaneous patch in postero-lateral corner of segments 3–6 dorsally, a castaneous streak near ventro-lateral margin on segments 1–7. Legs pale yellow. Cerci whitish, with narrow castaneous annulations. Wings clear, costal and subcostal areas pale yellow, leaving a clear white space around each of the indistinct cross-veins, except those in pterostigmal area, which are bright orange or burnt-sienna; a dark brown spot on either side of the cross-vein in costal area immediately before the bright pterostigmal cross-veins, and a more conspicuous dark spot, almost black, on either side of the cross-vein below the 1st bright pterostigmal cross-vein; apical cell in subcostal area, and the apical portion of apical cell in radial area suffused with dark brown.

Localities.—Salisbury, S. Rhodesia (May 1917, R. W. E. Tucker); near Erikson's Drift, Kunene River, Ovamboland (March 1923, K. H. B.).

Remarks.—Both specimens agree in having the prettily marked wings and the conspicuous dark brown spots, but the Kunene River specimen shows no castaneous markings on the abdomen.

Cloeon delicatissimum n. sp.

Imago.—♀. No cross-veins before bulla, 2–3 very faint and incomplete cross-veins in pterostigmal area; cross-veins almost absent in MA, M, and Cu areas, the one or two that are present being extremely faint. No cross-veins distally connecting Sc–R_1–R_2–$1R_2$.

Body 3 mm.; wing 3·25 mm.

Pale fulvous-brown, almost uniform, some of the mesothoracic joinings slightly darker and also the posterior margins of the abdominal segments. Wings clear, pterostigmal area clear or very slightly suffused, neuration pale brown. Cerci lost.

Locality.—Wolvenhoek Kloof, French Hoek (April 1931, K. H. B.).

Remarks.—Only 4 ♀♀ imagos of this species have been taken. Its small size and venational characters render it distinct from the other species. The nymph is unknown, and the species is therefore included in *Cloeon*.

Cloeon aeneum n. sp.

Imago.—♀. No cross-veins before bulla, several slightly oblique simple cross-veins in pterostigmal area, some of them incomplete. No cross-veins distally connecting Sc–R_1–R_2–$1R_2$.

Body 5 mm.; wing 5–5·5 mm.

Head yellowish, slightly darker medianly between eyes. Pro-, meso-, and meta-thorax warm brown, rather bronzy in life, mesothorax with lighter markings, in particular a dark-bordered light horizontal streak in front of base of wings, scutellum pale yellowish, with dark brown on either side; thorax paler ventrally. Abdomen brown, uniform, paler ventrally. Legs pale straw, with faint longitudinal suffusion on femora. Cerci lost. Wings hyaline, venation faint grey, a dark suffusion at base of Sc and R.

Localities.—Groot Drakenstein (A. C. H.); Jonkershoek, Stellenbosch (H. G. Wood); Lilyfontein, Kamiesberg (September 1931, K. H. B.); Grahamstown (Albany Mus.).

Remarks.—A considerably smaller species than *chaplini* and differing in the character of the fewer pterostigmal cross-veins. Differing in the same respect from *delicatissimum* as well as being larger. Only ♀ specimens have been found, in the months of March and April.

Cloeon chaplini n. sp.

Imago.—No cross-veins before bulla, 6–8 oblique, partly forked, but complete cross-veins in pterostigmal area occasionally one or two incomplete ones). No cross-veins distally connecting Sc–R_1–R_2–$1R_2$.

Body ♂ 7 mm., ♀ 9 mm.; wing ♂ 7 mm., ♀ 9·5 mm.; cerci ♂ 7·5 mm.

Head and prothorax brown. Mesothorax brown, with pale medio-dorsal line, and lighter marks laterally and ventrally. Metathorax brown. Abdomen raw-sienna dorsally, posterior margins of the segments slightly darker, burnt-sienna; ventrally pale creamy, a dark longitudinal stripe laterally immediately below the pleura on segment 9. Legs pale ochraceous. Cerci whitish, with faint narrow sienna annulations. Wings clear, costal area colourless but faintly opaque in pterostigmal area, neuration pale yellowish. ♀ like ♂ but paler.

Subimago.—Similar to imago, but abdomen paler, and the posterior margins of the segments brighter, orange-brown. Wings pale creamy, neuration very pale, cross-veins almost invisible.

Locality.—Jonkershoek, Stellenbosch (F. G. Chaplin, A. C. H., and K. H. B.).

Remarks.—This is the largest *Cloeon* yet found in South Africa. Specimens were taken in "Midsummer" and end of May by Mr. Chaplin, and in May by A. C. H. and K. H. B.

The absence of the distal cross-veins connecting Sc–R_1–R_2–$1R_2$ easily distinguishes the ♂ of this species from the clear-winged ♂ of *lacunosum*, and also from *perkinsi*.

Cloeon perkinsi n. sp.

Imago.—♀. No cross-veins before bulla, 4 (5) in pterostigmal area. Cross-veins connecting Sc–R_1–R_2–$1R_2$ distally present.

Body 5 mm.; wing 5·5 mm.; cerci 8 mm.

Head creamy-white, two orange-red or castaneous longitudinal stripes between eyes and ocelli, a narrow ring of the same colour around base of eye, basal joints of antennae with same colour dorsally. Prothorax white, with a broad medio-dorsal stripe of reddish-brown and a lateral stripe of the same colour on either side. Mesothorax creamy-white, the lateral prothoracic reddish stripe continued through base of wings, dorsum with two longitudinal pale drab stripes separated by a very narrow pale medio-dorsal line and continued as a single median stripe on scutellum, the sides of latter white. Metathorax with dorso-lateral reddish stripe continued, but broader. Pro-, meso-, and meta-thorax ventrally creamy-white. Abdomen creamy-white, a narrow medio-dorsal brick-red stripe, laterally a broad stripe of same colour, then a narrow white stripe followed on the pleurae by a narrow red line (*i.e.* there are dorsally five red stripes); ventrally creamy-white. Legs creamy, front femur suffused with orange. Cerci

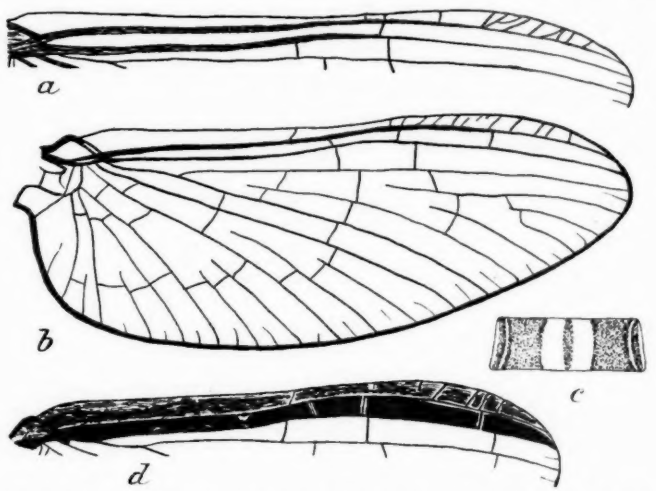


FIG. 7.—*Cloeon*. *a*, *chaplini* n. sp., marginal area of fore-wing ♀ subimago; *b*, *aeneum* n. sp., fore-wing ♀ imago; *c*, *d*, *perkensi* n. sp., abdominal segment and marginal area of fore-wing of ♀ imago.

white, with narrow red-brown annulations, which are much less numerous than the articulations. Wings clear, marginal area yellowish, subcostal area fulvous, both pellucid, cross-veins in marginal area opaque, pale yellow, the other cross-veins brownish like the longitudinal veins; by transmitted light the three submarginal cross-veins are dark, with very narrow hyaline borders.

Locality.—Worcester (town) (April 1931, A. C. H.).

Remarks.—A very pretty fly easily recognised by the five red stripes on the abdomen. Named after Mr. James Perkins of Worcester, who has been for very many years a keen angler.

Austrocloeon n. g.

Imago.—Like *Cloeon*. Cross-veins connecting Sc–R_1–R_2–$1R_2$ distally present or absent (as in *Cloeon*).

Nymph.—Like *Cloeon*, but labial palp apically clavate as in *Procloeon*, maxillary palp 2-jointed, slender, as in *Procloeon*, and 1st gill double, 6th and 7th single.

Remarks.—Lestage (1917, p. 131, fig. 6) has recorded nymphs from Lakes Tanganyika and Meru with the above-mentioned characters.

Austrocloeon africanum (E.-P.).

Esben-Petersen, 1913, p. 184, fig. 8 (♂ forceps); Esben-Petersen, 1920, p. 502; Lestage, 1924A, p. 343.

Imago.—No cross-veins before bulla, a single straight oblique cross-vein in pterostigmal area. No cross-veins distally connecting Sc–R_1–R_2–$1R_2$.

Body 4·5–5 mm.; wing 5–5·5 mm.; cerci 8–10 mm.

Head pale buff or biscuit, with orange longitudinal marks on occiput and along inner edge of eye, eyes black. Prothorax pale buff, with a small orange-brown spot on either side of median line, or each spot may be joined along the posterior margin to another smaller spot more laterally, forming a crescent-shaped mark. Mesothorax pale buff or biscuit, with orange and orange-brown markings and joinings, scutum with a median darker line, scutellum white, with brown on either side; laterally and ventrally whitish, with brown (clarety-brown) joinings. Metathorax with brown markings. Abdominal segments pale buff or biscuit, with orange-brown or clarety-brown markings as in figure, segments 2, 4, and 7 being the most conspicuously marked; pleurae whitish; ventrally whitish, with a round

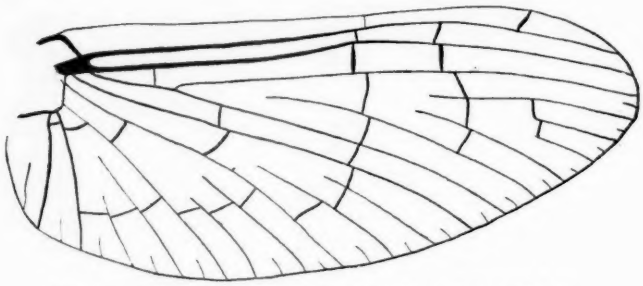


FIG. 8.—*Austrocloeon africanum* (E. P.). Fore-wing of ♀ imago.

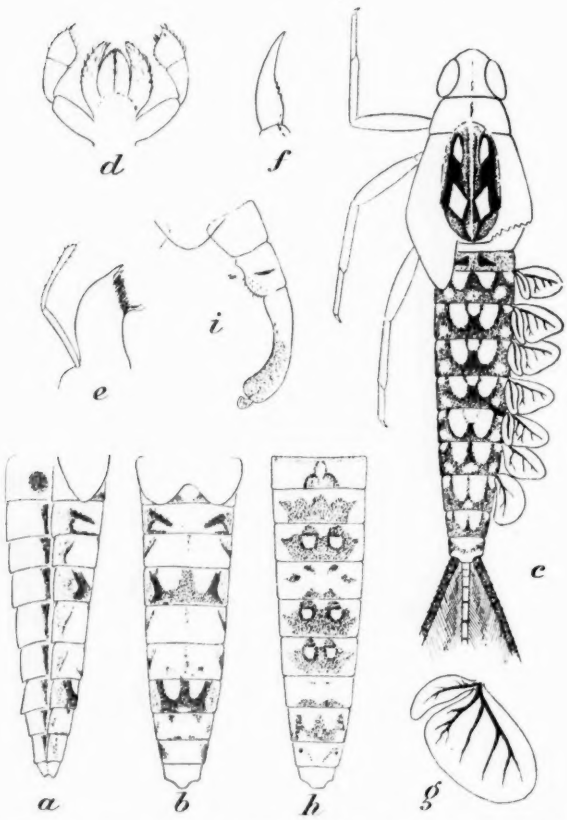


FIG. 9.—*Austrocloeon africanum* (E. P.). *a*, *b*, lateral and dorsal view of abdomen of imago; *c*, nymph; *d*, labium; *e*, maxilla; *f*, claw; *g*, 2nd gill; *h*, abdomen of nymph, showing a second variety of colour pattern; *i*, forceps of ♂ imago.

clarety-brown spot laterally on segment 1, and lateral streaks of same colour on segments 2–8 or 9. Legs pale buff. Cerci white, narrowly annulate. Wings clear, marginal area faintly yellowish, cross-veins distinct, opaque whitish or pale yellow.

Nymph.—Labial and maxillary palps as figured. Claws very feebly denticulate. Gills 1–5 double, 6 and 7 single; sometimes a very small upper lamella on gill 6.

Body 5 mm., cerci 2·5 mm.

Brown, with two very distinct pale oval or lozenge-shaped marks, bordered with dark brown or black, on either side of median line of mesothorax in advanced nymphs. Abdomen brown, with pattern as figured (two varieties), ventrally pale, with a brown stripe near lateral margin on each segment except 10. Legs pale, femora and tibiae suffused near apices. Cerci, outer ones brown, median one white, all three annulate.

Localities.—Zululand (September and December, W. E. Jones); Kimberley (J. H. Power); Resolution, near Grahamstown (Miss Walton); Dunbrody and Uitenhage (July 1925, K. H. B.); Pilgrims Rest, Transvaal (Schunke); Ceres (April, R. M. Lightfoot (All S.A. Mus.)). Groot Drakenstein (A. C. H.); Du Toits Kloof, Rawsonville (A. C. H.); Worcester (town) (A. C. H.); Sabi, Transvaal (nymphs only, June, July 1930, J. C. Dendy); Winkle Spruit, Natal (Natal Mus.); Fort Brown (Albany Mus.).

Remarks.—The identification is confirmed by the comparison of relaxed and moistened topotypes from Zululand, which show the same colour-pattern as the fresh material. Apart from the colour-pattern, the single pterostigmal cross-vein is distinctive. Lestage (1924A) assigns to this species, with some doubt, subimagos from Salisbury (S. Rhodesia) and Incomati (Delagoa Bay); and also Ulmer's specimens from the French and Belgian Congo, Cameroons, and Sudan, which he attributed to *marginale*.

Habits.—In the Cape the flies of this species occur in March and April.

Austrocloeon virgiliae n. sp.

Imago.—No cross-veins before bulla, two well-marked cross-veins in pterostigmal area. Cross-veins distally connecting $Sc–R_1–R_2–1R_2$ present.

Body ♂ 5·5 mm., ♀ 7 mm.; wing ♂ 6 mm., ♀ 7–7·5 mm.; cerci ♀ 9 mm.

♀ Head white, with two dark castaneous or claret longitudinal submedian stripes. Eyes French-grey, with a narrow claret line around base, and two horizontal dark stripes laterally. Prothorax white, with two submedian dark

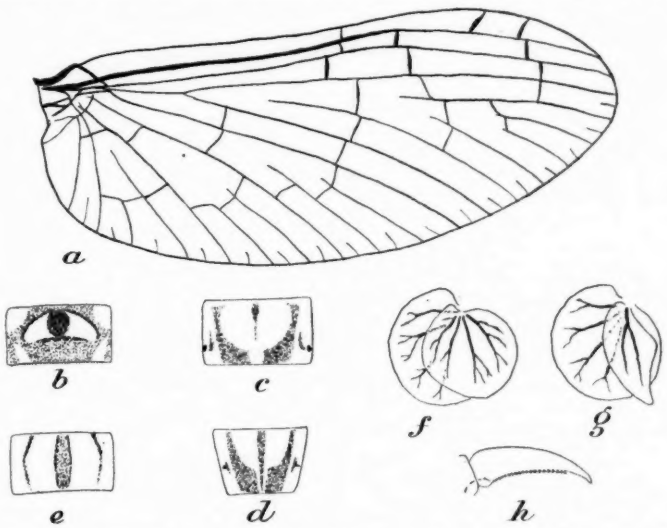


FIG. 10.—*Austrocloeon virgiliae* n. sp. *a*, fore-wing ♂ imago; *b*, dorsal abdominal pattern of nymph; *c*, *d*, dorsal pattern on abdominal segments 4 and 7 of subimago; *e*, ventral abdominal pattern of subimago; *f*, *g*, 3rd and 1st gills; *h*, claw of nymph.

claret stripes and a claret patch nearer the lateral margin. Mesothorax pale buff, with a medio-dorsal broad fawn stripe, narrowly bordered with white, scutellum white, bordered with dark claret; laterally and ventrally with orange-brown and claret speckling and joinings. Metathorax dorsally fawn, with a claret transverse bar anteriorly and posteriorly and a white patch laterally. Abdomen whitish, a medio-dorsal claret stripe on anterior segments, faint on posterior segments, a lateral claret patch on segments 1–3, and a smaller claret patch in postero-lateral corner of

segment 5; ventrally a medio-ventral claret stripe on segments 1–3 and 5, and a narrow claret stripe near the lateral margins on segments 1–3; segment 10 dorsally and ventrally suffused with claret. Legs whitish, femora suffused with orange-brown or claret. Cerci white, with narrow dark claret-brown annulations. Wings clear, costal and subcostal areas pale amber (♀) or pale yellow (♂), cross-veins conspicuous, those in marginal area opaque pale yellow, the others opaque milky-white.

Subimago.—Pale creamy-yellow. Head and prothorax with indications of the same marks as in imago. Mesothorax with some of the joinings marked with brown. Abdomen with pale claret-brown or reddish-brown medio-dorsal elongate spots or stripes and lateral patches, as figured, on segments 1–8, segment 9 with the lateral patches nearly or quite obsolete, segment 10 irregularly suffused; ventrally with the medio-ventral stripe and lateral marks as in imago and nymph. Cerci white, with orange or brownish annulations. Wings milky-white, especially the marginal area.

Nymph.—Similar to that of *africanum*, but with the inner (upper) lamellae of the gills broader, those of gills 2–5 being subcircular, and the claws much more strongly denticulate.

Body 5 mm.

Abdominal colour-pattern as figured (Groot Drakenstein). In the single Potteberg nymph-skin (from which the subimago was caught emerging) the two dorsal clear patches on either side of the median line are considerably contracted so as to form comma-shaped marks, with the tail of the comma pointing anteriorly.

Localities.—Keurbooms River, Plettenberg Bay District (side stream) (♂♂ January 1931, K. H. B.); Worcester (town) (♀ April 1931, A. C. H.); Jonkershoek, Stellenbosch (♀ May 1931, A. C. H. and K. H. B.); Potteberg, Bredasdorp District (May 1931, A. T. Packham); Groot Drakenstein (nymph, March 1931, A. C. H.); Clovelly, Kalk Bay, Cape Peninsula (May 1931, A. C. H.); Pietermaritzburg (May 1931, Natal Mus.).

Remarks.—Easily recognised by the two pterostigmal cross-veins and the coloration. Allied species with two pterostigmal cross-veins are *viridellum* Lest., 1923, from the Belgian Congo, and *Cloeon* sp. Ulmer, 1909 (Voeltzkow Reise, ii, p. 368, fig. 7), from Madagascar.

Variations occasionally occur; some specimens have 1 pterostigmal cross-vein on one wing and 3 on the other; one specimen had 2 on one side and 3 on the other. The presence of distal cross-veins below the pterostigmal area will easily separate aberrant or mutilated specimens of this species from *africanum*. The name is from *Virgilia capensis*, the Keurboom tree.

An olive-green nymph was found in watercress-beds at Clovelly, and the subimago emerged at 7 p.m., 31st May 1931. In this living subimago the ground-colour, under parts and legs were olive-green, but this colour faded to yellow after a few hours in alcohol.

Gen. *Pseudocloeon* Klap.

Ulmer, 1920, p. 125. (Non Bengtsson, 1914. = *Procloeon*.)

Imago.—Like *Cloeon*, but with the marginal intercalaries paired, at least in distal half of wing.

Remarks.—The position of the first cross-vein between R_1 and R_2 varies; *cf.* the figures of *jörgenseni* E. P. (Deutsch. Ent. Zeitsch., 1909, p. 551, fig. 2), and *obscurum* Ulmer (Notes, Leyden Mus., 35, 1913, p. 111, fig. 10). In the former it is oblique, meeting R_2 slightly distal to the origin of the cross-vein between R_2 and $1R_2$; in the latter it is its own length proximal to the cross-vein between R_2 and $1R_2$. In the species described below it varies in position. 1A not forked.

The nymph is known only for *vinosum* (*infra.*).

The genus has been recorded hitherto from Java, Chile and Argentine, Canada, and Cameroons.

Some small specimens (wing 4 mm.) of a species of this genus were collected on the Kunene River, Ovamboland (March 1923, K. H. B. and R. F. Lawrence), but are in too poor a condition for description.

Pseudocloeon vinosum n. sp.

Imago.—Paired intercalaries extending only to one space beyond MA, or to Cu_1, or to anal angle. First cross-vein between R_1 and R_2 slightly proximal, or opposite, or slightly distal to cross-vein between R_2 and $1R_2$.

Body ♂ 4·5–5 mm., ♀ 5–5·5 mm.; wing ♂ 5 mm., ♀ 5·5–6 mm.; cerci 7–8 mm.

Head pale ochre, medianly orange. Eyes black, ocelli white at tips. Prothorax brown, with orange transverse bar on anterior and posterior margins. Mesothorax dorsally castaneous brown, with pale yellow and darker brown markings, orange on humeral area, scutellum pale yellow, dark brown on either side; laterally and ventrally pale fulvous, with paler marks. Metathorax dorsally brown. Abdomen castaneous brown, with pale medio-dorsal stripe, on each segment a comma-shaped mark, the tail of the comma pointing posteriorly and followed by a pale spot on either side of median line, faint on segment 9 and absent on segment 10; ventrally paler fulvous, uniform. Legs pale ochre. Cerci whitish, uniform. Wings clear, faintly milky in pterostigmal area, neuration pale brown.

Nymph.—Of the Baetid type. Maxillary palp 3-jointed. Labial palp like that of *B. bellus* or *Centroptilum excisum*. Median cercus a little shorter than the others. Gills 6 pairs, none on 1st segment, broadly oval.

Up to 6 mm.

Brown, with the abdominal pattern of imago. Cerci sepia, apical third of all three whitish. Gills transparent, tracheae dark.

Localities.—Groot Drakenstein (October 1930, March 1931, A. C. H.); Silvermine Stream, Kalk Bay Mountains, Cape Peninsula (May 1931, A. C. H.); Schusters R., Simonstown (August 1931, A. C. H.).

Remarks.—Named from the wine-growing district in which the first specimens were found. The nymph has not yet been discovered.

Pseudocloeon magae n. sp.

Imago.—First cross-vein between R_1 and R_2 slightly proximal or slightly distal to cross-vein between R_2 and $1R_3$. Cross-veins in pterostigmal area as in *vinosum*, but faint.

Body ♂ 3·75–4 mm., ♀ 4 mm.; wing ♂ 3·75–4 mm., ♀ 4·25 mm.; cerci ♂ 7–8 mm.

♂. Eyes brown, turbinate eyes basally and on top orange or castaneous, with an intervening pale band. Promeso- and meta-thorax dorsally Vandyke brown, antero-laterally more or less suffused with orange, laterally and ventrally with pale marks and dark joinings. Abdomen brownish, with a fulvous or castaneous tinge, a faint medio-

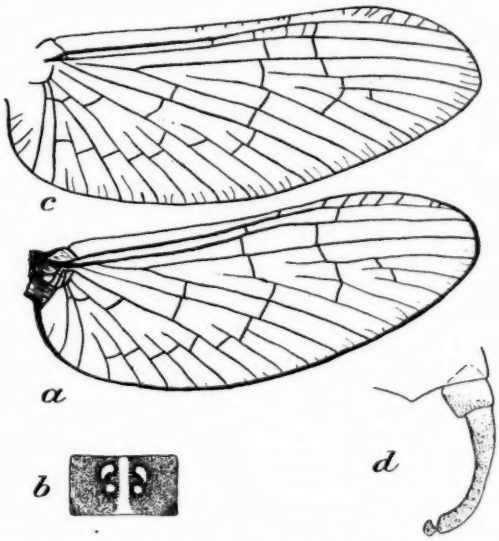


FIG. 11.—*Pseudocloeon vinosum* n. sp. *a*, *b*, fore-wing ♀ imago and abdominal pattern of imago. *P. magae* n. sp.; *c*, *d*, fore-wing of ♂ imago and forceps of ♂.

dorsal dark line, in some specimens forming a disconnected series of elongate spots, the most usual being a spot on each of segments 2, 6, and 8; ventrally pale greyish; a very narrow dark streak along the pleurae. Legs whitish. Cerci white, uniform. Wings clear, a faint milkiness in the pterostigmal area, and often the base of Sc and R at root of wing suffused with dark sepia. ♀ lighter, fulvous, mesothorax with pale marks and darker joinings.

Locality.—Hex River, Sandhills, Worcester District (April 1931, A. C. H.).

Remarks.—Distinguished from *vinosum* by its smaller size and coloration. (Maga, a witch, =Hex.)

In some of the ♂♂ some of the marginal intercalaries are single, not paired, and in both ♀♀ nearly all the intercalaries are single. This seems to show that the genus *Pseudocloeon* is somewhat insecurely based. The specimen figured is unusually heavily veined, showing paired intercalaries extending to the anal angle, and numerous very fine incomplete veinlets from C and a few also from Sc.

Gen. *Baetis* Leach.

Eaton, 1885, p. 156; Ulmer, 1920, p. 124; Lestage, 1921, p. 257 (nymph).

Imago.—Hind-wings small, elliptical or elongate-oval, usually with an acute process on front margin near base. with 2–3 veins, the 2nd sometimes forked, cross-veins very few or absent. Marginal intercalaries paired. 1A forked near margin. Cross-veins in fore-wing mostly in three dislocated series. Genital styles of ♂ 4-jointed, 3rd joint usually much the longest, 4th smallest. Front tarsus of ♂ subequal to tibia, slightly longer than femur. Claws dissimilar. Cerci 2, elongate in ♂. Eyes turbinate in ♂.

Nymph.—Eyes lateral. Antennae elongate. Mandibles with or without prostheca. Maxillary palp 2- or 3-jointed. Inner lobes of labium much narrower than outer lobes, palp 3-jointed, 3rd joint typically subcircular. Median lobe of hypopharynx without lateral processes, lateral lobes not curving outwards. Claws denticulate. Cerci 3, the median one shorter than the lateral ones. All gills single.

Remarks.—No flies of this genus have yet been recorded from Africa, but nymphs have been known (Ulmer, 1916) and described (Lestage, 1917, p. 123 *sqq.*). Lestage figures two species (figs. 2 and 3) with labial palps of the form found in the South African species *bellus*, described below.

Key to the South African Species.

1. Hind-wing oval, with costal process . . . . . *harrisoni.*
2. Hind-wing elongate, without costal process . . . . . *bellus.*

Baetis harrisoni n. sp.

Imago.—Hind-wing oval, twice as long as broad, with two veins, the second simple, but indications of an incomplete fork at the margin. 8–10 cross-veins in pterostigmal area in fore-wing, some incomplete, and with T or Y-shaped longitudinal branchlets.

Body ♂ 5·5 mm., ♀ 6·5–8 mm.; wing ♂ 6 mm., ♀ 7·5–9 mm.; cerci ♂ 10–11 mm.

Head reddish-brown. Eyes and ocelli black, the latter with white tips. Turbinate eyes in ♂ fulvous orange. Pro-, meso-, and meta-thorax pale castaneous, the mesothorax dorsally, with darker and lighter longitudinal bands, scutellum pale, with dark brown below. Abdomen in ♀ pale, dorsally with faint greyish suffusion forming a pattern, as in figure, corresponding with that of nymph, posterior margins of segments pinkish (or sienna in alcohol); in ♂ very pale, semi-transparent, except posteriorly, where it is opaque white. Legs pale buff. Cerci pale straw, uniform or very faintly annulate in ♂. Wings clear, neuration pale brown, pterostigmal area faintly suffused. Genital styles of ♂ white.

Subimago.—Similar, but paler. Turbinate eyes pinkish. Cerci white, uniform.

Egg.—Roundish-oval, ·14 mm. long diameter, surface smooth, no attachment threads, pale yellow.

Nymph.—Abdominal segments denticulate on posterior margin only on hinder segments, and only feebly if at all on ventral surface. Apex of mandible blunt, truncate, prostheca absent. Maxillary palp 2-jointed, the joints subequal. Labial palp typical. 3rd joint subcircular.

Femora with short spines on anterior margin, longer spines (especially basally) on hind margin, tibiae and tarsi with simple spines, claws strongly denticulate. Gills obovate, proximal margins sparsely setose, distal margin more or less densely setose, and minutely denticulate. Tracheae dark on all gills except 1st, where they are invisible or absent. Middle cercus about ⅔ length of the lateral ones.

Up to 8–9 mm., cerci 4–5 mm.

Straw or pale brown. Abdominal segments dorsally greyish-brown, the colour bounded in front by a thin dark line separating it from the pale articular membrane; a lighter more or less oval patch on either side of the median line, which is also pale, often a small dark spot on either side of median line, postero-lateral angles where gills are attached, and also on segments 8 and 9, dark; ventral surface pale cream or white. Legs pale straw, knees and to a lesser degree also the apices of tibiae and tarsi, dark. Cerci pale whitish, with an ill-defined dark area about in middle of the lateral cerci, and, in the distal third of the median cercus, base of the latter also usually dark. Gills transparent with dark tracheae and margins.

The abdominal pattern varies in intensity, being very distinct and almost sharply defined in some nymphs, in others almost uniform.

Localities.—Groot Drakenstein (A. C. H.); Jonkershoek, Stellenbosch (A. C. H. and K. H. B.); Eerste River, Lynedoch (E. J. Steer); Hex River, Sandhills, Worcester Distr. (A. C. H.); Du Toits Kloof, Rawsonville (A. C. H.); French Hoek (K. H. B.); Table Mt. slopes, Cape Town (K. H. B.); Silvermine Stream, Kalk Bay (A. C. H.).

Habits.—Full-grown nymphs ready to hatch have been obtained in October and January to August; the species therefore in all probability goes on throughout the year. On the Eerste River trout have been caught with their stomachs packed exclusively with these nymphs.

The nymphs are very active swimmers and impatient of captivity.

Baetis bellus n. sp.

Imago.—♀. Hind-wing elongate-oval, without costal process, with two subparallel veins. 6–7 complete, simple unbranched cross-veins in pterostigmal area.

Body 5 mm.; wing 5·5–6 mm.; cerci 6 mm.

Nearly uniform castaneous or burnt sienna, mesothorax laterally and ventrally, with pale ochraceous marks and joinings. Abdomen castaneous, darker laterally and on posterior margins of segments, a medio-dorsal darker patch on each segment, with a pale median stripe, very faint indications on anterior segments of the pale dots seen in subimago; ventrally pale. Legs ochraceous, suffused with orange. Cerci pale, faintly annulate. Wings clear, milky in pterostigmal area, neuration fulvous.

Subimago.—♀. Head pale, with sienna markings, leaving a pale space medianly, widening posteriorly. Prothorax pale, with central sienna transverse patch, behind which are two pale dots outlined in dark brown. Mesothorax dorsally reddish or sienna, with a faint medio-dorsal line and horizontal pale streak, outlined in black, from base of wing, scutellum pale. Metathorax sienna. Thorax laterally and ventrally paler sienna or yellowish. Abdomen segment 1 sienna with a medio-dorsal pale spot on posterior margin; segments 2–9 sienna, with a faint medio-dorsal pale line, and two pairs of pale spots in anterior half, the anterior spots comma-shaped, with the tail of the comma pointing anteriorly, a short dorso-lateral pale streak in postero-lateral corner; segment 10 pale sienna; ventrally all segments whitish. Legs pale straw, margins of femora and tibiae, and all the tarsi, suffused with grey. Cerci whitish, faintly annulate.

Nymph.—Apex of mandible denticulate. Labial palp with 2nd joint apically expanded on inner margin, 3rd joint ovate. Maxillary palp 3-jointed. Claws strongly denticulate. Median cercus half length of the lateral ones. Gills as in *harrisoni*, but 1st gill with a simply branched trachea.

Body 5 mm.

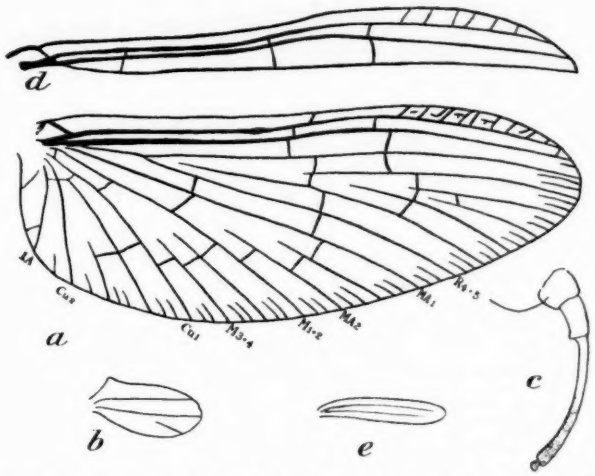


FIG. 12.—*Baetis harrisoni* n. sp. *a*, *b*, fore- and hind-wings ♀ imago; *c*, forceps of ♂. *Baetis bellus* n. sp. *d*, *e*, fore- and hind-wing ♀ imago.

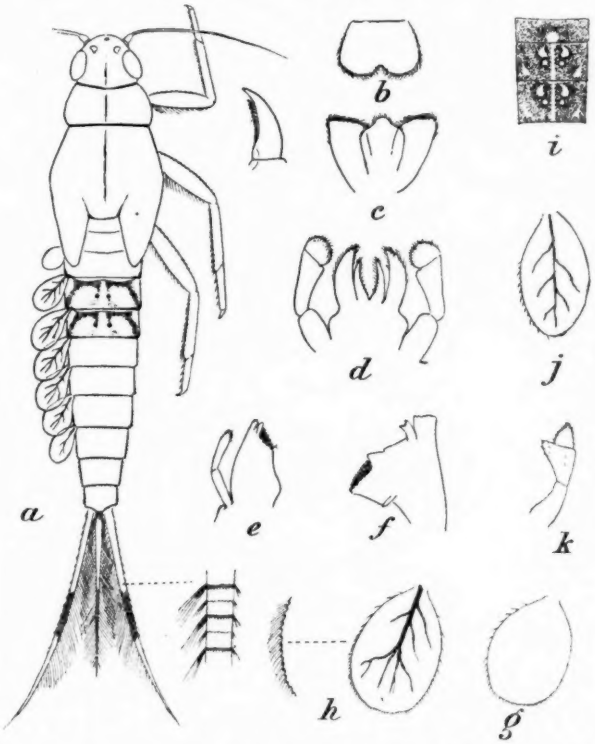


FIG. 13.—*Baetis harrisoni* n. sp. *a*, nymph, with claw and portion of lateral cercus further enlarged; *b*, labrum; *c*, hypopharynx; *d*, labium; *e*, maxilla; *f*, left mandible; *g*, *h*, 1st and 3rd gills. *Baetis bellus* n. sp. *i*, abdominal pattern of nymph; *j*, 2nd gill; *k*, labial palp.

In fully-grown nymph, coloration and colour-pattern as described for subimago, the pro- and meso-thoracic markings not so clearly defined. Femora and tibiae with a greyish suffused band across the middle.

Localities.—Groot Drakenstein (A. C. H.); Jonkershoek, Stellenbosch (A. C. H.); Clovelly, Kalk Bay, Cape Peninsula (A. C. H.); Wellington Mts. (October 1931, K. H. B.).

Remarks.—Flies of this pretty species have been obtained in March, April, and May. At first sight the abdominal pattern appears very like that of *Pseudocloeon vinosum*, but on closer inspection the comma-shaped marks are seen to point in the opposite direction.

The species resembles the English species *atrebatinus* in the narrow hind-wings without costal process. This character easily distinguishes it from *harrisoni*, even in the subimago. The labial palp of the nymph does not conform to the typical *Baetis* character in the 2nd and 3rd joints.

Gen. *Centroptilum* Eaton.

Eaton, 1885, p. 174; Ulmer, 1920, p. 124; Lestage, 1921, p. 255 (nymph).

Imago.—Hind-wing small, narrow and elongate, with an acute spur-like process on costal margin basally, 1–2 simple longitudinal veins. Marginal intercalaries in fore-wing single. Cross-veins mostly in three dislocated series. Genital styles of ♂ 4-jointed (except in *tenellus*, where only 3-jointed). Front tarsus of ♂ rather longer than tibia, which is twice as long as femur. Claws dissimilar. Cerci 2. Eyes turbinate in ♂.

Nymph.—Similar to that of *Baetis*, except: gills more acutely ovate, especially the 1st (if present). Mandible with fine setae on molar. Labial palp with 3rd joint typically minute. Median cercus sometimes very short.

Key to the South African Species.

1. Hind-wing with bifid costal process in both sexes . . . . . *sudafricanum*.
2. Hind-wing in ♂ with slender hook-like process, in ♀ hind-wing aborted . . . . *excisum*.

Remarks.—Only one species of this genus is known from South Africa, but other species are known from the Belgian Congo, Sudan, and Comoro Isles. Lestage (1917, p. 128, fig. 4) describes a nymph from Kitutu River, Belgian Congo, with 2-jointed maxillary palp, and a labial palp exactly like that of *sudafricanum*, but with 7 pairs of gills. The second species described below has 7 pairs of gills, but differs markedly in the labial palp. Its main feature, however, is the suppression of the hind-wing in the ♀, in the subimago almost completely, and completely in the imago.

A specimen of *Centroptilum* was collected on the Kunene River, Ovamboland (March 1923, K. H. B.), but is too damaged for description.

Centroptilum sudafricanum Lest.

Lestage, 1924A, p. 344.

Imago.—Hind-wing with two subparallel veins, costal process bifid, scabrous. In fore-wing no cross-veins before bulla, 3–4 in pterostigmal area, oblique, usually complete, with intervening short incomplete veinlets.

Body 4·5–5 mm.; wing 5 mm.; cerci 7·5–9 mm.

♀. Head pale brown, paler on occiput between eyes. Pro-, meso-, and meta-thorax brown, somewhat castaneous, pale ventrally; mesothorax dorsally uniform. Abdomen castaneous-brown, paler ventrally, uniform. Legs brown. Cerci pale brown, faintly annulate. ♂ darker. Turbinate eyes pale cream at base, reddish-castaneous on top.

Subimago.—Paler, with indications on the abdominal segments of the pale chevrons found in the nymph.

Nymph.—Labium and labial palp typical, though the inner lobes are rather slender. Mandible with prostheca. Claws strongly denticulate. Only 6 pairs of gills, the 1st pair completely aborted. Median cercus only half-length of the lateral ones.

Up to 5–6 mm.

Greyish-brown, thorax faintly mottled in young nymphs, uniform castaneous in full-grown nymphs. Abdomen greyish-brown, paler ventrally, an indistinct pale lateral border, and a pale V-shaped mark (apex posterior) on hind margins of the posterior segments, more strongly marked in young than in older nymphs, segment 10 pale. Legs pale biscuit, femora faintly suffused, with a dark band in distal third. Cerci pale. Gills semi-transparent, tracheae and margins black.

Localities.—Groot Drakenstein (A. C. H.); Hex River, Sandhills, Worcester Distr. (A. C. H.); Cedarbergen, Clanwilliam Distr. (K. H. B.); Table Mt. slopes, Cape Town (K. H. B.); Keurbooms River, Plettenberg Bay Distr. (K. H. B.); Zwartberg Pass, Prince Albert Distr. (K. H. B.); Jonkershoek, Stellenbosch (H. G. Wood); Krantzkop, Natal (November 1917, K. H. B.); Shefton Grange, Natal (Natal Mus.); Genadendal (K. H. B.).

Remarks.—The absence of the 1st pair of gills in the nymph is noteworthy. In the flies I can find no differences between the topotype material from Krantzkop and the Cape examples.

Some nymphs from Sabi, Transvaal (June, July 1930, J. C. Dendy), seem to belong to this species.

Habits.—In the Cape nymphs have been found in March, April, September, October, November, and January, and the flies also in January, March, April. The subimagos emerge from the nymph on the underside of stones (one stone leaning across or up against another) above the water-line.

Centroptilum excisum, n. sp.

Imago.—♂. Hind-wing with two subparallel veins, costal process hook-like, slender, scabrous apically. In ♀ hind-wing completely aborted. In fore-wing no cross-veins before bulla, 6–8 cross-veins in pterostigmal area, oblique, some occasionally incomplete or with intervening short incomplete veinlets.

Body ♂ 5–5·5 mm., ♀ 6–6·5 mm.; wing ♂ 5·5–6 mm., ♀ 7 mm.; cerci ♂ 8 mm., ♀ 6 mm.

♂. Eyes black. Turbinate eyes pale yellow below, castaneous above. Prothorax dark brown. Mesothorax Vandyke brown, dorsally shining, very dark, almost piceous, with light joinings on humeral region, scutellum dark;

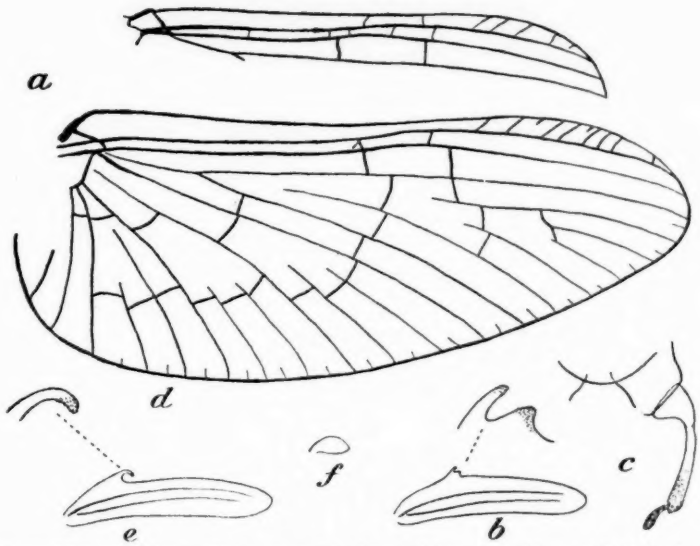


FIG. 14.—*Centroptilum sudafricanum* Lest. *a*, marginal area of fore-wing of imago; *b*, hind-wing; *c*, forceps of ♂. *C. excisum* n. sp. *d*, fore-wing ♂ imago; *e*, hind-wing ♂ imago; *f*, hind-wing ♀ subimago.

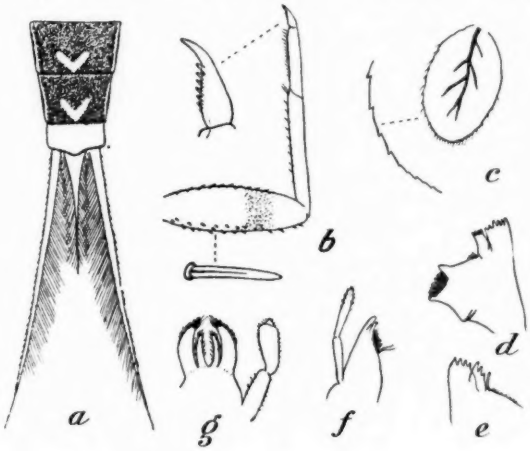


FIG. 15.—*Centroptilum sudafricanum* Lest. *a*, end of abdomen, and cerci, of nymph; *b*, front leg; *c*, gill; *d*, left mandible; *e*, apex of right mandible; *f*, maxilla; *g*, labium. *C. excisum* n. sp. *h*, abdominal pattern of nymph; *i*, labium; *j*, gill; *k*, claw.

laterally and ventrally with pale ochraceous or orange marks and joinings. Metathorax dark brown. Abdomen raw sienna, with reddish-orange or burnt sienna medio-dorsal and lateral stripes on all segments except 10; ventrally pale whitish. Legs suffused greyish. Genital styles of ♂ white. Cerci white, uniform. Wings clear, slightly milky in pterostigmal area, neuration pale yellowish-white. ♀ Lighter in colour. Head pale ochraceous, orange between ocelli. Eyes and ocelli black, tips of latter white. Prothorax brown, with lighter marks and joinings, scutellum ochraceous, brown on either side; laterally and ventrally paler. Abdomen brown, posterior margins slightly darker, medio-dorsal and lateral orange stripes as in subimago sometimes visible; ventrally pale whitish. Cerci white. Wings as in ♂.

Subimago.—Hind-wings in ♀ minute. Pale ochraceous. Turbinate eyes pinkish on top. Abdomen with the orange or sienna medio-dorsal and lateral stripes more conspicuous on the paler ground colour than in the imago, the white chevron-marks of the nymph also showing.

Nymph.—Apices of mandibles denticulate. Maxillary palp 2-jointed. Inner lobes of labium not so narrow as in *sudafricanum*, 2nd joint of palp strongly expanded inwards at apex, 3rd joint well developed, ovoid. Claws denticulate at base only. Gills 7 pairs, ovate-lanceolate.

Up to 6–7 mm.; cerci 3 mm.

Head and thorax brown, with lighter mottling and markings. Eyes black. Abdominal segments brown, segments 7, 8, and 10 usually paler than the others, a medio-dorsal chevron-like pale mark near anterior margin, and a pale lateral longitudinal stripe, antero-lateral angles of each segment pale, semipellucid, postero-lateral angle with dark border; the chevron marks are usually broken up into two pairs of dots on segment 9, and not visible at all on segment 10; ventrally paler, uniform, sometimes suffused with orange on anterior segments. Legs whitish, more or less suffused, knees dark. Cerci pale.

Localities.—Groot Drakenstein (April, May, June 1930, 1931, A. C. H.); Clovelly, Kalk Bay, Cape Peninsula (May 1931, A. C. H.); Table Mt. slopes, Camps Bay, Cape Peninsula (May 1931, K. H. B. and H. G. Wood); Glencairn, Cape Peninsula (June 1931, A. C. H.); Lilyfontein, Kamiesberg (September 1931, K. H. B.).

Remarks.—The partial reduction of the hind-wing in the ♀ subimago and its complete abortion in the ♀ imago is noteworthy. The labium of the nymph is different from that of *sudafricanum*, and resembles very closely that of *Baetis bellus*. For the present the species may be left in *Centroptilum*.

Habits.—Flies have been found in April, May, and June. At Clovelly, Kalk Bay, the nymphs were found in great numbers in the watercress bordering the sandy bed of the Silvermine stream in May and June. Many were seen to rise to the surface and disclose the subimago. Spinner flights were observed in this locality on bright, windless days (A. C. H.).

Gen. *Centroptiloides* Lest.

Lestage, 1918, p. 107, and 1924A, p. 340; Ulmer, 1920, p. 125, and 1920A, p. 52.

Imago.—Hind-wings comparatively broad, with a small acute costal process followed by a more obtuse process, three longitudinal veins, the middle one more or less clearly forked, and one or two marginal intercalaries, cross-veins few and very faint. In fore-wing marginal intercalaries single; 1A simple; cross-veins in three dislocated series. Front tarsus of ♂ subequal to or slightly shorter than tibia, but longer than femur, tibia 1–1½ times length of femur; claws dissimilar. Genital forceps of ♂ 4-jointed, 3rd joint elongate, 4th slender, pyriform. Cerci 2. Eyes turbinate in ♂.

Nymph.—Unknown.

Centroptiloides bifasciatum (E.-P.).

Esben-Petersen, 1913, p. 182, figs. 4–7; Lestage, 1918, p. 108, and 1924A, p. 341; Lestage, 1924A, p. 341 (*marginatum*).

Remarks.—From a study of the material in the South African Museum it is clear that *marginatum* is merely a synonym of *bifasciatum*. One or other of the branches of the middle vein in hind-wing is often actually disconnected

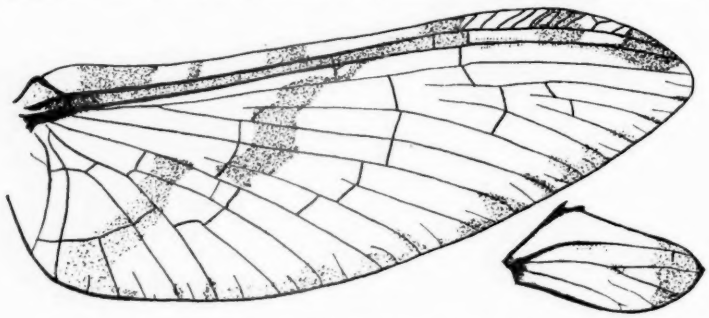


FIG. 16.—*Centroptiloides bifasciatum* (E. P.). Fore- and hind-wings ♂ imago.

from the stem, or so faintly connected as to appear disconnected; this character therefore is too inconstant to be used as a specific character. Even from a glance at the labels on the specimens it seemed strange that Mr. Jones's

assiduous collecting in one locality should produce one species in the years 1914 and 1924, and another species in the previous and intervening years.

The cross-veins and the two costal processes in the hind-wing are better defined in the subimago than in the imago.

In addition to the Zululand locality, a subimago ♀ was taken on the Kunene River, Ovamboland (March 1923, K. H. B.).

Ulmer (1920A, p. 53) mentions having seen a specimen from the Cameroons.

Gen. *Acentrella* Bgntsn.

See addendum, p. 259.

Family Brachycercidae.

Ulmer, 1920, p. 120 (*Caenidae*); Campion, 1923 (Ann. Mag. Nat. Hist. (9), xi), p. 515.

Imago.—Wings milky or smoky, margin setose (in imago as well as in subimago). Sc well developed, separate from R. MA forked. No short marginal intercalaries. Hind-wings absent. Cerci 3, very long in ♂. Tarsal claws in front leg of ♂ either alike or dissimilar.

Nymph.—Crawling type, living in muddy situations or in rapid streams. Antennae moderately long. Mandible with prostheca. Maxillary palp 3-jointed. Labial palp 3-jointed. Cerci 3. Gills 5 or 6 pairs of varying character.

Remarks.—The discovery of the nymph of the true *Tricorythus* (as distinct from the American *Tricorythodes*) raises the interesting question of the rightful inclusion of this genus in the family *Brachycercidae*, which is discussed below.

In 1920 Needham described a Brachycercid and its nymph from the Belgian Congo, for which he instituted the genus *Caenopsis* (*C. fugitans*). Lestage (1925, Ann. Biol. Lac., vol. xiii, pp. 254, 259, 264) claims this as a synonym of *Tricorythus*, and speaks of the nymph as that of a true *Tricorythus*. But the wing venation alone shows that it is not a *Tricorythus*, and *a fortiori* if the nymph described below for *Tricorythus discolor* proves to be typical for the other species, *Caenopsis* cannot possibly be a synonym. *Caenopsis* would seem to be a perfectly valid genus, allied more closely to the " Caenid " series than the *Tricorythus* series, though the ♂ genitalia are certainly Tricorythoid in character.

Key to the South African Genera.

Imagos.

1. The two intercalaries between Cu_1 and Cu_2 forming a long narrow fork. Cross-veins few, in a single series. *Austrocaenis.*
2. The two intercalaries forming a short broad fork. Cross-veins numerous, more or less in three series. *Tricorythus.*

Nymphs.

1. 1st gill rudimentary, filiform; 2nd gill elytroid, covering the following 3rd–6th pairs . . . *Austrocaenis.*
2. 1st gill obsolete; gills on 2nd–6th segments double, outer lamella oval, elytroid, inner composed of several imbricate lamellae . . . . . *Tricorythus.*

Austrocaenis n. g.

Imago.—Prothorax broader than long, front coxae well separated. Wings broadest in cubital region. The two intercalaries between Cu_1 and Cu_2 arising near base, forming a long narrow fork. Cu_2 and 1A subparallel, convergent at base. Cross-veins uniserial. Front tibia of ♂ much longer than femur. Genital styles of ♂ 1-jointed; penis broadly lamellar, undivided. Tarsal claws of front legs of ♂ alike, of mid and hind legs, and of all legs of ♀ dissimilar.

Nymph.—Prothorax broader than long. Abdominal segments 3–9 shortly produced postero-laterally. Maxillary palp with 2nd and 3rd joints subequal. Lobes of labium distinct, inner lobes longer than broad, palp with 3rd joint much the shortest. Femora stout; front claws smooth, mid and hind claws minutely setulose. 1st gill rudimentary, filiform; 2nd gill forming a subquadrangular elytroid cover, nearly completely concealing the 3rd–6th gills, without tracheate tuft on under surface; 3rd–6th gills oval, with long fimbriate marginal processes, no tracheate tufts on under surface. Lateral ocelli near inner margin of eyes.

Egg.—Ovoid, sculptured, with attachment threads arising from both poles.

Remarks.—Resembling *Brachycercus* Curtis (=*Eurycaenis* Bgtsn.) in the broad prothorax, both in imago and nymph, but otherwise with the characters of *Ordella* Camp. (=*Caenis*).

Austrocaenis capensis n. sp.

Eaton, 1884, p. 142 (*Caenis* sp. undescr.).

Imago.—Prothorax in ♂ slightly wider than long, narrowing in front, hind margin concave, lateral margin angular; in ♀ twice as wide as long. All abdominal segments except 1 and 10 in both sexes produced laterally in acute points, which are slender on the anterior segments, becoming stronger posteriorly. Genital styles of ♂ slender, gently curved, minutely setulose apically, extending slightly beyond penis, whose lateral and distal margins are concave. Ventral plate in ♀ transverse, distal margin gently convex. Cerci setose in ♀, naked in ♂.

Body ♂ 5 mm., ♀ 4–6 mm.; wing ♂ 4–5 mm., ♀ 5–6·5 mm.; cerci ♂ 15–17 mm., ♀ 4–6 mm.

Head, prothorax and abdomen creamy-white, the abdominal segments more or less suffused dorsally with grey, the terminal segment in ♂ often orange. Mesothorax and metathorax dorsally and laterally more or less bright

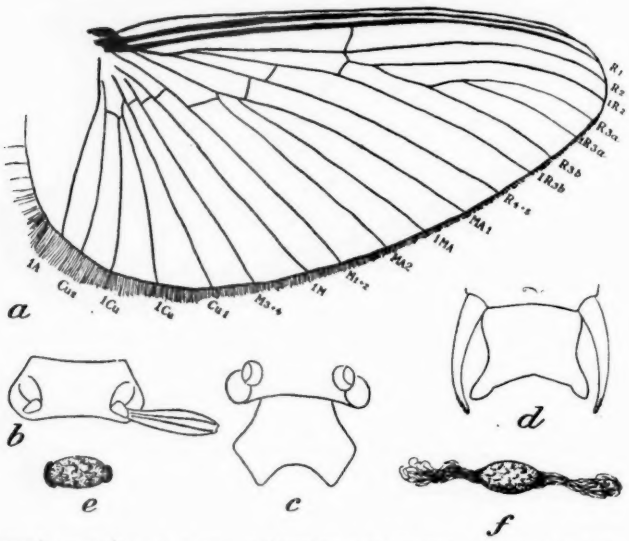


FIG. 17.—*Austrocaenis capensis* n. g., n. sp. *a*, forewing ♀ subimago; *b*, ventral view of prothorax ♀; *c*, dorsal view of prothorax ♂ imago; *d*, forceps and penis of ♂; *e*, *f*, egg, before and after uncoiling of the attachment threads.

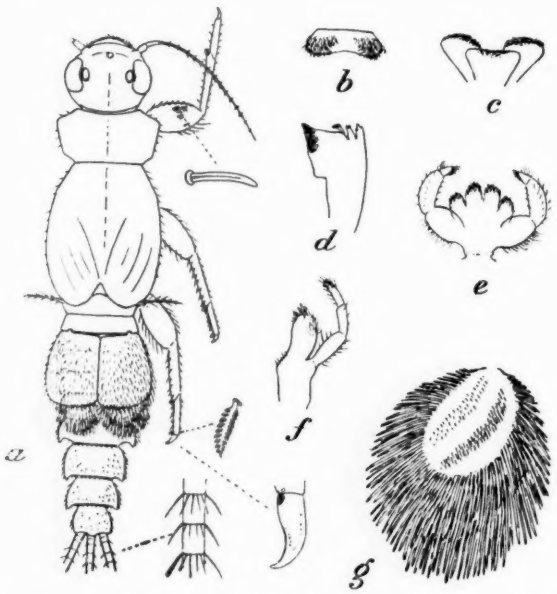


FIG. 18.—*Austrocaenis capensis* n. g., n. sp. *a*, nymph, with claw, spines, and portion of cercus further enlarged; *b*, labrum; *c*, hypopharynx; *d*, mandible; *e*, labium; *f*, maxilla; *g*, gill.

orange (pale buff in alcohol), ventrally white. Legs white, front coxa and trochanter suffused with grey, front femur with two longitudinal grey streaks on upper edge and two on lower edge, front tibia streaked with grey on outer edge. Bases of antennae white. Eyes and ocelli black, apices of lateral ocelli white. Cerci uniform white. Wings hyaline, C, Sc, and R with an orange tinge (grey in alcohol).

Subimago.—Similar, but cerci in ♂ setose, and wings milky.

Egg.—Oval, shallowly sculptured, with attachment threads at each pole. Before the eggs are laid these threads form a compact knob at the pole; when the eggs touch the water the threads uncoil and become entangled with other eggs and vegetation in the water (*cf.* Ulmer, Notes Leyden Mus., vol. xxxv, p. 107, fig. 7, 1913). The eggs are at first pale yellow, later orange, and when ready for deposition, depending from the abdomen of the ♀, black.

Nymph.—Abdominal segments 3–9 produced postero-laterally in short acute points. Ocelli distinct, the lateral ones close to the inner margins of eyes. Femora stout, oval, front femur with an irregular transverse series of stout flattened spines; mid and hind tibiae and tarsi more strongly spinose than front tibia and tarsus, the tarsi with 2–3 pectinate spines on inner apex; claws smooth in front leg, minutely setulose in mid and hind legs. Median cercus slightly longer than lateral ones; all with setae on both margins at intervals. Elytroid gill covers of the 2nd gills setose on margin and upper surface; 3rd–6th gills with two bands of outwardly directed spine-setae on upper surface; marginal fringes simple near base, mostly bifid apically.

Up to 8 mm.; cerci 5 mm.

Uniform pale brown.

Localities.—Lakeside, Cape Peninsula (A. C. H. and K. H. B.); Jonkershoek, Stellenbosch (A. C. H. and K. H. B.); Groot Drakenstein (A. C. H.); Du Toits Kloof, Rawsonville (A. C. H.); Worcester (town) (A. C. H.); Keurbooms River, Plettenberg Bay Distr. (side stream) (January 1931, K. H. B.); Potteberg, Bredasdorp Div. (A. T. Packham).

Remarks.—Eaton, in 1874, found a single drowned ♀ at Cape Town, which he did not describe. The species has remained unknown until the present time, although it is exceedingly abundant at Lakeside. It probably occurs in all the lakes on the Cape Flats. The life-history has been worked out by Mr. Harrison on Lakeside material.

Habits.—The species inhabits ponds and pools, with still or slowly flowing water, and an abundance of weed and algae. The nymphs are found amongst the weed, but to large extent burrow in or crawl over the mud and ooze on the bottom, and it is difficult to get specimens which are not covered with particles of foreign matter.

The flies hatch in swarms in July, August, November, December, February, March, April, May. Emergence takes place by night, or sometimes by day in dull weather, and the flies are dead by morning. Swarming was observed on one occasion at 7 a.m. on a dull, rainy morning (March).

Austrocaenis ? sp.

A minute ♂ imago was collected in the Schuurftebergen, east of Citrusdal (February 1928, K. H. B.), and may represent a second species of this genus.

Body 2 mm.; wing 2·25 mm.; cerci 6 mm.

Eyes black. Pro- and meso-thorax fulvous brown. Abdomen pale sepia. Legs, femora pale grey, tibiae and tarsi whitish. Cerci pale grey. Wings almost clear, marginal area faintly milky.

Gen. *Tricorythus* Eaton.

Eaton, 1884, p. 138; Lestage, 1918, p. 95; Ulmer, 1920, p. 122; Navas, 1926 (Broteria, vol. xxiii), p. 100.

Imago.—Wings almost hyaline or milky or smoky, broadest in cubital region. The two intercalaries between Cu_1 and Cu_2 not arising at base, forming a short broad fork. Cu_2 and 1A subparallel, divergent at base. Cross-veins multiserial. Legs short, half length of body; front tibia of ♂ not longer than femur. Genital styles of ♂ 2- or 3-jointed; penis narrow. Cerci 3. Abdominal segments not produced postero-laterally. Tarsal claws all dissimilar in both sexes.

Nymph.—Flattened ventrally, dorsally convex. Antennae moderately long. Labrum not or scarcely incised. Mandible very strong, projecting and forming the lateral margin of head, with thick fringe of long setae on outer margin, prostheca distinct. Maxilla oblong, with apical and ventral brushes of setae, palp slender, 3-jointed, 3rd joint minute, unguiform. Hypopharynx with median lobe incised, outer lobes subtriangular, not curving outwards. Labium with outer and inner lobes completely fused into a subtriangular plate, palp moderate, 2nd joint long, ensiform, with marginal fringe of long setae, 3rd joint minute, unguiform. Femora stout, claws with only two denticles. Cerci 3. Gills consisting of five pairs situate on segments 2–6, each double, the outer lamella oval, elytroid, the inner lamella bifid, each branch carrying two series of imbricate lamellae; no gill on segment 1.

Remarks.—The genus comprises five African and one Javanese species.

The discovery of the nymph of this genus (the nymph described by Cockerell and Gill, Univ. Colorado Stud., 3, 1906, belongs to *Tricorythodes* Ulmer) raises some interesting questions.

The retention of the fringe of setae on the wings of the imago, albeit not so prominent as in typical Brachycercids, and the venation seem to indicate that *Tricorythus* is a Brachycercid, though the abdominal segments are not laterally acuminate, and the front tibia in ♂ is not very long.

Ulmer (1920, p. 120) has suggested the division of the family into two groups, one containing *Brachycercus* and *Ordella*, the other containing *Tricorythus* and three other genera, which appear to be closely related to the *Ephemerellidae*. At least the nymph of *Tricorythodes*, according to Ulmer, seems to denote this affinity (*loc. cit.*, p. 123). This last statement is based on Morgan's description of the larva of a North American "Tricorythus" (Ann. Amer. Ent. Soc., vol. iv, 1911. This paper is not accessible to me, but a figure of the labium occurs in Murphy, 1922, Bull. Lloyd. Libr., No. 22; Entom. Ser., 2, pl. v, fig. 64).

Two features of the adult *Tricorythus discolor* bear analogy with some of the Ephemerellids. The South African *E. barnardi* and *T. discolor* have the same peculiar armature of the genital styles of the ♂. This may be only a minor

point; its value is difficult to access because such minutiae are seldom figured. But the armature is totally different from that of the other South African forms here studied.

The penis of *T. discolor* seems to resemble very closely that of *Ephemerella invaria* figured by Eaton (pl. xiv, fig. 24*c*). This feature again probably has little or no significance because the penis of *E. ignita* is broad (pl. xiv, fig. 24*a*), more like that of *E. barnardi*.

When the nymph of *Tricorythus* is examined, although at first sight it looks very like the nymph of *Ephemerellina*, it is found that there is no character which is really Ephemerellid except the gills. These are of the same imbricate type as those of *Ephemerella* and other genera, though the double series of lamellae on each rachis is unique; in fact, they are far more Ephemerellid in character than those of *Ephemerellina*, where the outer lamella of 1st gill becomes definitely elytroid and covers all the other gills, as in typical Brachycercids. The gills, therefore, are not conclusive as to affinities.

Of the other features: a similar fringe of setae on the mandible is found in the burrowing nymph of *Palingenia*, thefemora with their arrangement of clavate spines are paralleled by those of *E. barnardi*, the labium is nearest to that of *Tricorythodes*, with the glossae and paraglossae completely fused, and the maxilla seems to be *sui generis*, though with some resemblance to the Leptophlebiid maxilla.

The femora are clearly adaptations to a habitat in rapidly flowing water, and the modifications of the mouth-parts would seem to form a wide-spreading net or basket for the capture of particles of food brought down by the current.

One other feature may be mentioned, namely, the fusion of the wing-cases. This seems to be carried further than in any of the described forms of Ephemerellid nymphs, and indicates the course of evolution of the remarkable *Prosopistoma* which, it may be noted, is also an inhabitant of swift currents (*cf.* Lestage, 1921, p. 179).

Apparently, therefore, the criteria for deciding on the systematic position of *Tricorythus* must be taken from the adult. Possibly the discovery of the nymphs of *Leptohyphes* and *Leptohyphodes* will provide a way out of the difficulty, even to the extent of instituting a separate family for *Tricorythus* and its allies, between the *Ephemerellidae* and the *Brachycercidae*.

A second very remarkable species of this genus has been discovered in the Cape.

Tricorythus discolor (Burm).

Eaton, 1884, p. 139; Esben-Petersen, 1913, p. 181, figs. 2, 3; Lestage, 1924A, p. 338.

Imago.—Longitudinal and cross-veins all more or less equally well developed, the radial veins nearly straight (not wavy). 1–3 faint cross-veins before bulla, 4–6 (7) beyond bulla. Ventral plate of ♀ ovate, feebly notched at apex. Genital styles of ♂ 2-jointed, 2nd joint with minute papillose armature along inner margin. Penis with a

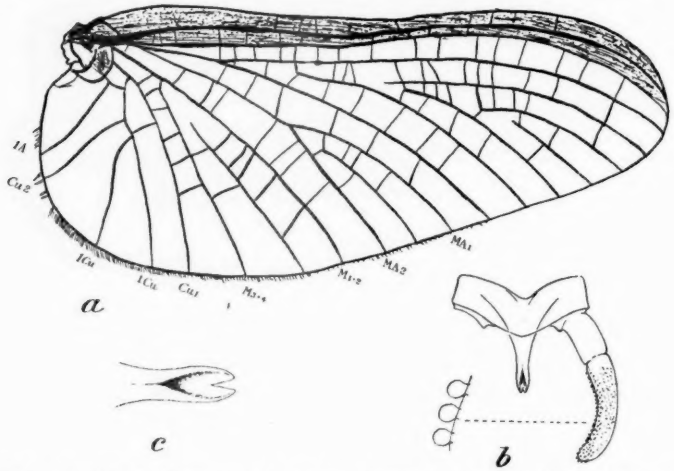


FIG. 19.—*Tricorythus discolor* (Burm.). *a*, fore-wing ♂ imago; *b*, forceps and penis of ♂, with armature of forceps further enlarged; *c*, ventral view of apex of penis further enlarged.

short apical cleft dorsally, ventrally with a shallow excavation into which apparently the vasa deferentia open. Cerci of both sexes setose.

Body ♂ 6·5–7 mm., ♀ 7–7·5 mm.; wing ♂ 6 mm., ♀ 10–11 mm.; cerci ♂ 12–15 mm., ♀ 10–12 mm.; fore-leg and hind-leg ♂ 3·5 mm., ♀ 5 mm.

Head black, a pale whitish patch between lateral ocelli and eyes. Eyes black, ocelli black with white apices. Antennae pale. Prothorax black or sooty dorsally and ventrally. Mesothorax pale fulvous (chiefly due to the inter-

nal tissues), with sooty suffusions, ventrally fulvous on either side of the sternite, which is sooty. Metathorax pale fulvious with sooty margin, ventrally sooty. Abdomen dark grey, sooty, with posterior margins of the segments narrowly black, ventrally paler. Legs sooty, longitudinally striped with darker and paler lines. Cerci grey, articulations of the joints slightly darker but less noticeable in fresh material than in dry. Genital styles and penis whitish. Wings sooty-grey, marginal area more suffused than rest of membrane.

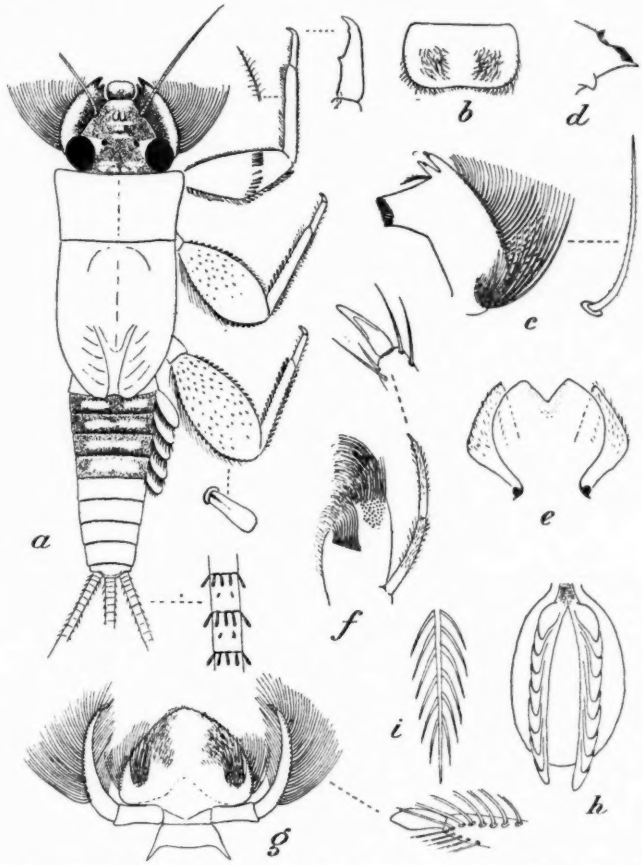


FIG. 20.—*Tricorythus discolor* (Burm.). *a*, nymph, with claw, femoral spine, and portion of cercus further enlarged; *b*, labrum; *c*, ventral view of left mandible; *d*, apex of right mandible; *e*, hypo-pharynx; *f*, maxilla, with apex of palp further enlarged; *g*, labium, with apex of palp further enlarged; *h*, inner view of gill; *i*, diagram of one rachis of inner lamella of gill.

Subimago.—Similar but body paler, femora white, with conspicuous black edges, cerci whitish, uniform; wings, on the other hand, more darkly suffused.

Egg.—Bluntly oval, surface reticulate, attachment threads from one pole only (apparently), pale yellow in body, orange when ready for deposition.

Nymph.—Body quite flat ventrally. Head not really very large, but appearing so on account of the projecting mandibles. Ocelli small, the lateral ones some little distance from the antero-internal border of eyes. Labrum transverse, scarcely if at all emarginate. Mandibles very large and strong, projecting laterally and forming the whole of the lateral margins of the head, prostheca distinct, outer margin with a series of close set long spine-setae, which proximally curves round on to the lower surface, each seta bears minute setules on both margins, but can scarcely be called plumose. Maxilla oblong, apex obliquely truncate, with a brush of long setae, lower surface also with a

patch of long setae near outer margin and an oblique row of long curved spine-setae, palp slender, long, 1st and 2nd joints subequal, setose, 3rd minute, unguiform. Hypopharynx with median lobe widely excised at apex, outer lobes subtriangular, a dark chitinous knob basally at junctions of outer lobes and median lobe. Labium with outer and inner lobes completely fused, without any traces of sutures, palp moderately stout, 2nd joint long, ensiform, with long spine-setae (of same type as those on mandibles) on both inner and outer margins, 3rd joint minute, unguiform. Legs stout, femora with clavate spines forming a transverse series on upper surface in front femur, and marginal series on mid and hind femora, with scattered ones on upper surfaces, front tibia with plumose setae, clavate spines on inner margin of mid tibia, and on both margins in hind tibia, claws with one denticle in middle of inner margin and another near apex. Wing-cases fused almost to their apices. Abdominal segments without dorsal projections, and not imbricate, posterior margins of all segments dorsally denticulate, ventrally smooth, postero-lateral angles not acuminate. No trace of gills on segment 1. Gills on segments 2–6 double, slightly decreasing in size posteriorly, the outer lamella oval, margins not setose, inner lamella bifid, each half consisting of a central rachis bearing two series of delicate imbricate lamellae. Cerci verticillate, with stout clavate spines and very fine setules.

Up to ♂ 6–7 mm., ♀ 9–10 mm. Cerci about as long as body.

Dark sepia-brown, mottled. A white spot between each lateral ocellus and eye. Eyes black. Mandibles and other mouth-parts bright ochraceous or fulvous. Abdomen dark sepia, the margins of the anterior segments darker than the slightly lighter central portions, posterior segments uniform. Legs pale ochraceous, more or less suffused, the spines dark brown, tarsi apically pale. Cerci warm brown, with a few paler annulations proximally. Outer lamellae of gills pale whitish, inner lamellae blackish-grey.

Young nymphs (2 mm., excl. cerci) are pale, with sepia suffusion dorsally, legs and cerci pale whitish.

Localities.—Tulbagh (April 1892, L. Peringuey); Michell's Pass, Wolseley (April 1931, A. C. H.); Hex River, Sandhills, Worcester Distr. (April and December 1930, A. T. Packham; April and October 1931, A. C. H.); Zululand (October 1911, W. E. Jones); Smithfield, O.F.S. (Dr. Kannemeyer).

Remarks.—Two of the ♂ and one of the ♀ specimens examined by Esben-Petersen are now in the South African Museum, and prove to be subimagos, not imagos. This accounts for the darker colour of the wings given in Esben-Petersen's description. It also accounts for Esben-Petersen thinking that the Smithfield specimen, which is also in the S.A. Museum, was a different species. It is in fact a ♀ imago, and is indistinguishable from Cape and Zululand specimens (*cf.* Lestage, 1924A, p. 340).

Habits.—The flies appear throughout the spring, summer, and autumn months in successive swarms. The subimagos emerge towards evening (5 p.m. in April) and take a short flight to the nearest stone (or angler) where they rest with wings outspread horizontally and pressed against the rock like a Geometrid moth. The imago appears in about an hour's time. The life of the imago is very fleeting, lasting only about an hour (A. C. H.).

The unique resting position of the subimago suggests that the rapid change to the imago may be correlated; the outspread position against the sun-warmed rocks helping to dry up and loosen the subimaginal pellicle.

The nymphs are very abundant, and all stages are found together. They cling to stones and rocks in swiftly running streams, and their remarkable structure is evidently adapted to withstand torrential currents. They are far more difficult to dislodge from a stone than are the nymphs of *Afronurus* or *Ephemerellina* (A. C. H.). The flat ventral surface appears to be pressed closely to the substratum, and is most probably made to function as a vacuum by retraction of the central portions; the flattened femora also aid in adhesion. When the front femora are moved forwards, the head fits into the slightly concave basal portion, proximal to the transverse rows of clavate spines, as in *Ephemerellina*. The clavate spines on the mid and hind femora and tibiae, and on the cerci, probably abut against irregularities of the surface of the stone, and help to stem the animal against the push of the water from in front or from the side.

In still water in captivity they live only a short while (14 days).

When several nymphs are placed in a glass jar without objects to which to cling, they cling to one another in a tight mass (cf. *Prosopistoma*, Lestage, 1921, p. 179).

Tricorythus reticulatus n. sp.

Imago.—♀. Wing more uniformly broad than in *discolor*. Longitudinal veins from Sc to M very distinctly curved distally for a short distance before meeting the margin of wing. All veins in Rs field between R_2 and R_{4+5}

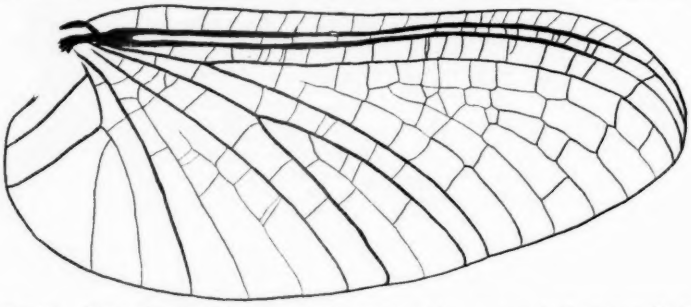


FIG. 21.—*Tricorythus reticulatus* n. sp. Fore-wing ♀ imago, marginal setae omitted.

feebly developed, and tending to form a more or less irregular network, the longitudinal veins wavy. 1MA, 1M, M_{3+4} and both 1Cu also less distinct than the other longitudinal veins.

Body 4–5 mm.; wing 8 mm.

Head blackish. Mesothorax fulvous. Abdomen light sooty-grey, the posterior margins of the segments darker. Legs grey. Cerci pale. Wing pale greyish.

Locality.—Tradouw Pass, Langeberg Range, east of Swellendam (October 1925, K. H. B.).

Remarks.—This species is not only smaller than *discolor*, but is easily distinguished by the reticulate veining in the Rs field. The ♂ is as yet unknown.

Family Leptophlebidae.

Ulmer, 1920, p. 112.

Imago.—Wings hyaline, with numerous cross-veins. Fore-wing with distinct, well-developed subcosta; MA forked; M_{3+4} and Cu_1 parallel, not separated by disconnected intercalaries; Cu_2 at base nearer to 1A than to Cu_1 (often only slightly so); Cu_2 and 1A curving sharply back, abutting on margin near base. Hind-wing well developed. Genital styles of ♂ 3-jointed, 2nd and 3rd joints very short; sometimes with only one short terminal joint clearly demarcated from the long basal joint; sometimes a short annular joint at base of long joint, making four joints. Penis entire or bilobed. Eyes in ♂ turbinate. Cerci 3.

Nymph.—Of the crawling type, more or less flattened. Head oblong, more or less bent downwards, eyes lateral, lateral ocelli at level of anterior margin of eyes. Antennae moderate or rather long. Labrum more or less apically excavate. Mandibles stout, outer margin more or less strongly convex, forming the antero-lateral margin of head, prostheca distinct. Maxillae oblong, apically truncate with a thick brush of setae, and a row of pectinate spines, palp 3-jointed. Hypopharynx with median lobe apically incised, with or without lateral forwardly curving processes, outer lobes (paragnaths) more or less curving outwards. Labium with inner lobes much smaller than outer, palp 3-jointed. Legs moderately stout, claws denticulate or smooth. Gills seven pairs, each consisting of a double or single lamella, of various shapes. Cerci 3.

Key to the South African Genera.

Imagos.

1. Claws all alike, narrow, hooked.
   - *a.* Hind-wing without angular costal process, costal area narrow, long . . . . *Aprionyx.*
   - *b.* Hind-wing with angular costal process, costal area broad, short . . . . *Adenophlebia.*
2. Claws unlike, one hook-like, the other obtuse.
   - *a.* Stalk of MA long, forking broad, considerably distal to origin of R_{4+5} from Rs . . *Castanophlebia.*
   - *b.* Stalk of MA shorter, forking narrow, a short distance distal to origin of R_{4+5} from Rs.
     - i. Genital styles ♂ 4-jointed, 1st joint annular. Hind-wing broadly oval . . *Choroterpes.*
     - ii. Genital styles ♂ 3-jointed. Hind-wing narrowly oval . . . . *Euthraulus.*

Nymphs.

1. Claws smooth. Abdominal segments 8 and 9 laterally biacuminate . . . . . *Aprionyx.*
2. Claws denticulate. Abdominal segments 8 and 9 laterally uniaculeate.
   - *a.* Gill on segment 1 not reduced.
     - i. Gills ovate-lanceolate . . . . . *Adenophlebia.*
     - ii. Gills narrow-lanceolate . . . . . *Castanophlebia.*
   - *b.* Gill on segment 1 reduced to a single filiform process.
     - i. Each lamella of gills 2–7 ending in three digitiform filaments . . . *Euthraulus.*
     - ii. Each lamella of gills 2–7 indented in middle, distal half abruptly narrower than basal half. *Choroterpes.*

Aprionyx n. g.

Eaton, 1884, p. 83 (*Atalophlebia* part); Ulmer, 1920, p. 115 (*Atalophlebia* part).

Imago.—Like *Atalophlebia*, *i.e.* claws of all legs alike, apically hooked. Hind-wing with costal margin convex, without strongly projecting process, the summit of the arch before middle of wing; Sc long; costal area long and narrow, subcostal area broader than costal area. 10th sternite of ♂ undivided. Genital styles of ♂ with two distinct terminal short joints, basal joint more or less abruptly narrowed in its distal half. Penis single, broad basally, more or less rapidly tapering, with a recurved flap near each orifice, sometimes apically cleft, but the lobes not dehiscent.

Egg.—Ovoid, sculptured with large pits, no projecting bosses, no attachment threads.

Nymph.—Claws quite smooth. Antennae long. Labrum shallowly emarginate, with denticles in the emargination. Hypopharynx with forwardly curving lateral processes on median lobe. Labium with inner lobes ovate, set in a vertical plane at right angles to the outer lobes, palp stout, terminal joint very short, broader than long, triangular, with short stout spines. Shoulder of prothorax with a patch of long slender spines. Abdominal segments 8 and 9 with two spines at each postero-lateral angle. Gills double, more or less obovate, with fine apical filamentous point.

Remarks.—This genus is closely allied to *Atalophlebia* Eaton and *Atalonella* Needh. and Murphy, 1924, but is distinguished by the smooth nymphal claws (α-πριων-ὀνυξ). The nymph of the genotype of *Atalophlebia*, viz. *australis*, is unknown; but in all probability it has toothed claws like the New Zealand species described by Phillips (1930). Nymphs attributed to the Chilean species of *Atalophlebia* and the closely allied *Atalonella* are described by Needham and Murphy (1924) as having toothed claws.

The labial palp is quite different from that figured for a Chilean *Atalophlebia*, but resembles in its stoutness and

very short 3rd joint that of the New Zealand species *cruentata* (Phillips, 1930, p. 347, fig. 15), though not that of *versicolor* (*ibid.*, fig. 1).

The egg is quite different from those described by Phillips.

Referring to Needham and Murphy's (1924, p. 36) tabulation of the venational differences between Chilean *Atalophlebia* and *Atalonella*, it may be noted that *Aprionyx* resembles *Atalonella* in having oblique pterostigmal cross-veins, M_{3+4} nearer to Cu_1 than to M_{1+2} at base, Cu_2 curved throughout its length; but agrees with *Atalophlebia* in having cross-veins before the bulla in subcostal area, and in the hind-wings. The penis in both genera is represented as divided into two lobes from the base, whereas in *Aprionyx* it is entire or with only a slight apical cleft.

Needham and Murphy (1924, p. 36) also state that the inner lobes of labium in *Atalophlebia* are conical, widened in *Atalonella*. This may perhaps be a misconception. In the South African nymphs the two inner lobes lie not in the same horizontal plane as the outer lobes, but side by side vertically; consequently if the appendage be viewed without compression these lobes appear narrow and more or less conical, but under a cover-slip ovate (in fig. 24 they are represented as flattened).

As the fore-wings and abdominal patterns of all the Cape species are here figured, a key or synopsis is unnecessary.

Aprionyx tabularis (Eaton).

Eaton, 1884, p. 91, pl. x, fig. 16*h*. Esben-Petersen, 1920, p. 500, figs. 3, 4. Lestage, 1924A, p. 325 (*phoeocera*).

Imago.—Ten fine cross-veins before bulla, 12–14 in pterostigmal area, very oblique, sigmoid, and nearly all anastomosing, some cases so much so as to form almost a longitudinal vein between C and Sc. Hind-wing with Sc extending to ⅓–¼ length of wing; 12–13 cross-veins in subcostal area. Genitalia ♂ as figured, penis not angular ventrally when viewed laterally, rather abruptly narrowed towards apex, which is shallowly cleft.

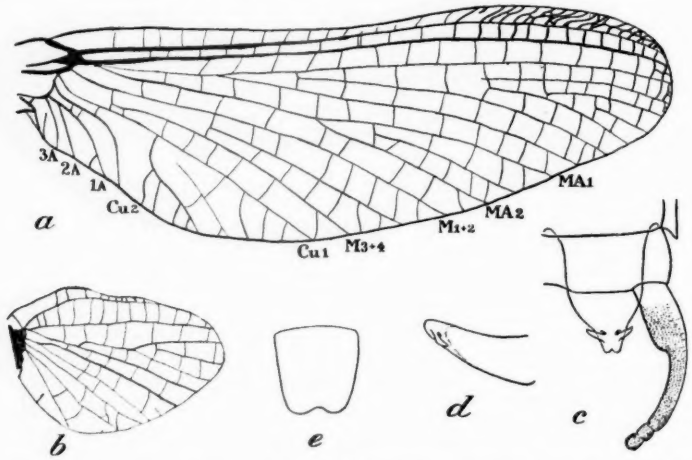


FIG. 22.—*Aprionyx tabularis* (Eaton). *a*, *b*, fore- and hind-wings ♂ imago (from Ceres. Determined by E.-P.); *c*, ventral view of forceps and penis of ♂; *d*, lateral view of penis; *e*, ventral plate of ♀.

Body ♂ 9 mm., ♀ 12 mm.; wing ♂ 10 mm., ♀ 13 mm.; cerci.

♂. Head and thorax dark Vandyke brown, junctions of sclerites on mesothorax laterally paler. Turbinate eyes dark basally, light pinkish (in alc.) on top, ocelli with white apices. Legs dark fuscous, femora suffused at apices and broadly across middle. Abdomen sepia-brown, segments 1, 9, and 10 uniform or nearly so, segments 2–7 or 8 with a medio-dorsal pale narrow stripe, with a pale round or oval spot on either side anteriorly and a fainter spot more posteriorly and laterally (*cf.* nymph), pleurae pale with dark margins; ventrally pale grey, segments 2–6 or 7 with two very faint darker specks near anterior margin. Neuration dark fuscous-brown, the costal and subcostal areas in the pterostigmal region slightly milky. Cerci ochraceous, the articulations of the joints slightly darker. Genital styles ♂ brown, the inner margin of the curved portion whitish, penis apically pale.

Subimago.—Similar, but darker, the scutum of mesothorax with a lateral dark border enclosing two dark longitudinal stripes, scutellum pale. Wing membrane greyish. When freshly emerged, with a slaty bloom; fades to a much paler tint in alcohol.

Egg.—Oval, twice as long as broad, ·25 mm. long diameter, sculptured with coarse shallow pits, no attachment threads.

Nymph.—Posterior margins of abdominal segments 9 and 10 with strong denticles, of the other segments with very minute and obscure, more or less bifid denticles, quite obsolete on the anterior segments. Segments 4–7 laterally acuminate, segments 8 and 9 with two acute points at postero-lateral angles; a minute second denticle occurs also

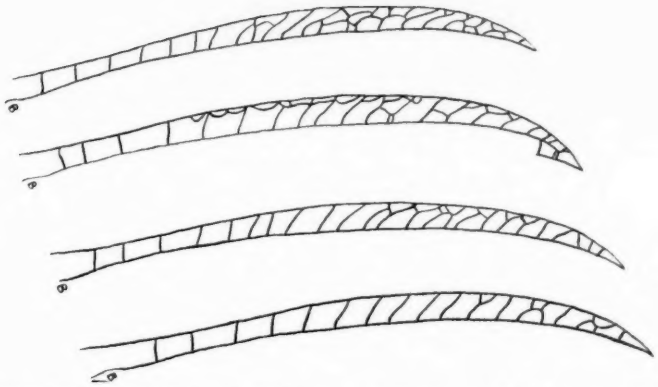


FIG. 23.—*Aprionyx tabularis* (Eaton). Varying degrees of anastomosis of the pterostigmal veins in four ♀ subimagos. Compare the same area in *A. intermedius*, fig. 27.

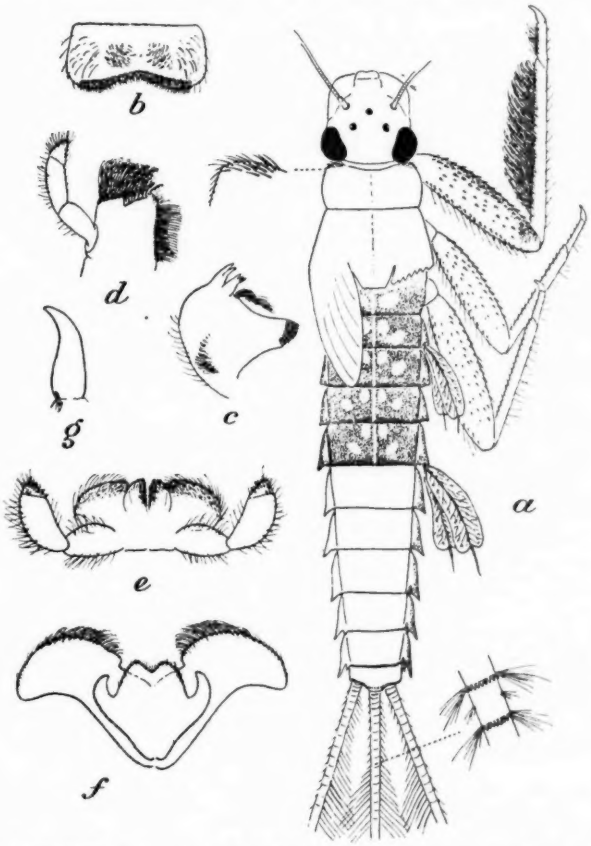


FIG. 24.—*Aprionyx tabularis* (Eaton). *a*, nymph with right wingcase cut away and some of the gills omitted, antennae and cerci cut short, colour pattern indicated on anterior abdominal segments only, prothoracic shoulder spines and portion of middle cercus further enlarged; *b*, labrum; *c*, left mandible; *d*, maxilla; *e*, labium (inner lobes flattened); *f*, ventral view of hypopharynx; *g*, claw.

sometimes within the lateral point on segments 6 and 7. Femora, especially front femur, rather stout. Front tibia and tarsus stronger than the others, with thick fringe of hairs on inner margin. Claws smooth. Gills slightly obovate, apically truncate, with a shallow notch from which arises the slender terminal filamentous point; 1st gill narrower than the others. Cerci elongate, verticillate, both margins of the median cercus and the inner margin of the lateral cerci rather thickly clothed with long setae, some plumose.

Mottled brown. Femora suffused at apices and along front margin, but no distinct bands. Metathorax brown with a faint median paler stripe with an oval pale spot on either side. Abdominal segments 1–9 with pale median stripe, with a round spot on either side anteriorly and a slightly larger obliquely ovate one posterior to it, pleurae pale with darker margins. Cerci brown, uniform, only the articulations of the joints slightly darker. Gills greyish-white, semi-opaque, tracheae black.

Up to 16 mm., antennae 9 mm., cerci 20 mm.

Localities.—Table Mt., Cape Town (1874, A. E. Eaton); Ceres (village) (April 1913, R. M. Lightfoot); Groot Drakenstein (A. C. H.); French Hoek (K. H. B.); Jonkershoek, Stellenbosch (A. C. H. and K. H. B.); Du Toits Kloof and Louws Hoek, Rawsonville (A. C. H.).

Remarks.—There is considerable variation in the pterostigmal cross-veins, and fig. 23 shows four varieties. The smaller specimens show the least amount of anastomosis. Such specimens remind one very forcibly of Eaton's description of *tabularis*, and the numbers of cross-veins before and after the bulla also agree.

Esben-Petersen's figure 3*a* (1920) of the penis closely resembles in outline Eaton's figure 16*h*, and it is to be noted that Lestage in his key (1924, p. 331) uses the same simile to describe Esben-Petersen's figure ("en forme de plume à écrire") as does Eaton ("the nib of a pen"). Yet Lestage declines to admit the correctness of Esben-Petersen's identification because the latter states that the cerci are uniform and the femora are dark only at the knees.

In fact, both in the specimens seen by Esben-Petersen and in fresh material, the cerci are annulate, albeit not strongly, and the femora are banded in the middle and dark at the knee.

There are only two reasons against designating this form as *tabularis*: the shape of the penis and the negative evidence that up to the present no specimen, fly or nymph, of an *Aprionyx* has been found in the Platteklip stream, Table Mt., where Eaton caught his original specimen.

As regards the penis, Esben-Petersen's figure was made from a dry specimen. If one examines the specimen under a low power in the dry condition his figure is accurate. But the figure is valueless, as he does not describe the penis or state whether it is bilobed or not.

Eaton's figure, from a specimen in alcohol, may be assumed to be more reliable. But it shows the penis deeply cleft into two lobes. This condition is found in *Choroterpes* and *Euthraulus*; but a still better likeness is found in the subimago (not the imago) of *Castanophlebia* (which latter *does* occur in the Platteklip stream). But apart from other considerations, the hind-wings and the venation of the fore-wings of all these genera are so different from those of *tabularis* as to preclude any confusion.

It therefore seems reasonable to use Eaton's name for this species, which agrees exactly in the number of costal cross-veins.

Lestage's name, *phoeocera*, was based not on actual specimens but on Esben-Petersen's description, which has been shown to be inaccurate, and therefore falls into synonymy.

Whether *tabularis* has become extinct or very rare in the Table Mt. streams is a matter for further investigation.

Habits.—The eggs are dropped in clusters as the female dips to the surface of the water. The larger open pools seem to be favoured, and the act was observed in the forenoon in warm sunny weather in April. A captured ♀ laid egg-masses in a tube of water; the eggs separated as they sank to the bottom. They hatched after 22–23 days. The first instar measures ·5 mm. plus cerci, and is hyaline yellow, no sign of gills (A. C. H.).

Nymphs of 7 mm. length are easily recognisable as belonging to this species by the characteristic "stance," the fringed front tibiae being held forwards aggressively. In captivity nymphs have been seen to pass the mouth-parts over the fringe on the front legs (A. C. H.).

Nymphs occur under stones in running water, and swim fairly well, using legs and body undulations.

The flies occur in March to June.

Aprionyx peterseni (Lest.).

Lestage, 1924A, p. 328.

Imago.—Five strong cross-veins before bulla; 8–9 strong ones in pterostigmal area, all simple, slightly oblique. Hind-wing with Sc extending about $\frac{1}{4}$ length of wing, seven cross-veins in subcostal area. Penis ventrally angular, apically entire. Ventral plate of ♀ sharply incised.

Body ♂ 9·5–10 mm., ♀ 10·5 mm.; wing ♂ 9–11 mm., ♀ 10–11 mm.; cerci ♂ 15–20 mm., ♀ 13–15 mm.

Head white with a dark brown or black median stripe, and a disconnected transverse stripe between its posterior end and the eye; a castaneous patch between the median stripe and the lateral ocelli, around which is also a castaneous ring. Eyes and ocelli black. Prothorax white with black crescentic marks and castaneous suffusion mediodorsally, and a black margin. Mesothorax dorsally black, scutellum white, laterally white with blackish and brown marks. A black bar across the "chest" in front of bases of middle legs, followed by two suffused spots on the sternite. Metathorax dorsally brown with a median pale mark. Abdominal segment 1 brown with a median conical pale spot and an oval pale spot on either side. Segments 2–7 white, pellucid, with a conical dark patch, containing an oval white spot on either side of median line, and a dark line on posterior margin; pleurae with a black mark anteriorly and posteriorly; ventrally with a very faint H-shaped mark. Segment 8 more suffused; segment 9 brown; segment 10 pale whitish. Femora pale with basal, middle and apical bands; tibiae and tarsi pale. Cerci white with dark annulations, the white and brown sections about equal in length. Neuration dark brown or blackish. Turbinate eyes in ♂ black basally, deep yellow (pinkish in alc.) distally.

Subimago.—Similar, but thorax with less brown mottling, mesothorax medio-dorsally white in centre, wings cloudy and neuration not so dark.

Egg.—Resembling that of *tabularis*.

Nymph.—In general like that of *tabularis*, but pleurae not so prominent, front tibia and tarsus without long fringe of hairs, cerci not so strongly setose.

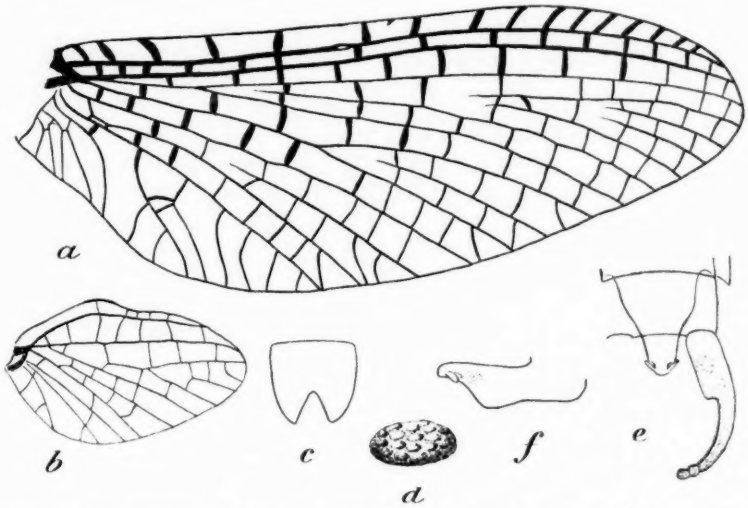


FIG. 25.—*Aprionyx peterseni* (Lest.). *a*, *b*, fore- and hind-wings ♀; *c*, ventral plate of ♀; *d*, egg; *e*, ventral view of forceps and penis of ♂; *f*, lateral view of penis.

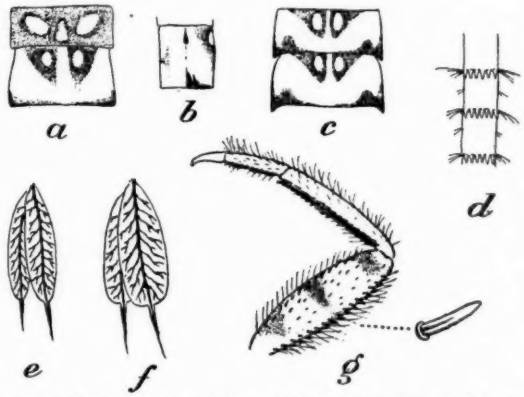


FIG. 26.—*Aprionyx peterseni* (Lest.). *a*, dorsal view of 1st and 2nd abdominal segments of imago; *b*, lateral view of segment 2 of imago (dorsum to right); *c*, dorsal view of 2nd and 3rd abdominal segments of nymph; *d*, portion of middle cercus of nymph; *e*, *f*, 1st and 2nd gills; *g*, front leg of nymph.

Brownish, mottled. Abdomen pale, with the same style of pattern as in the imago; in half-grown nymphs this seems to show only on the posterior segments; ventrally pale with a minute short black line on posterior margin on either side. Cerci annulate. Lamellae of gills not apically indented.

Up to 12 mm., antennae 4 mm., cerci 12–15 mm.

Localities.—Paarl (Rev. G. Hawke); Groot Drakenstein (A. C. H.); Jonkershoek, Stellenbosch (A. C. H.);

French Hoek (April 1931, K. H. B.); Montagu (October 1919, K. H. B.); Witte River, Wellington Mts. (November 1922, K. H. B.); River Zonder End Mts. (November 1928, K. H. B.); Bosch Kloof, Keeromberg, Worcester (January 1930, K. H. B.); Cedarbergen, Clanwilliam Distr. (January 1930, K. H. B.).

Habits.—The nymph crawls out, or partly out, of the water before emergence of the subimago. The emergence of both subimago and imago is crepuscular or nocturnal, the latter about 22–24 hours after the former. The flies appear in spring (October) and go through the summer to April in successive hatchings. The species is common, but not so common as *tabularis* or the "September" and "Summer Browns."

Aprionyx intermedius n. sp.

Subimago.—8–9 cross-veins before bulla; 12–14 in pterostigmal area, slightly oblique, and often slightly sigmoid, but rarely anastomosing. Hind-wing with Sc extending about $\frac{2}{3}$ length of wing, seven cross-veins in subcostal area. Ventral plate ♀ shallowly incised.

Imago.—♀. Penis much broader and flatter (dorso-ventrally depressed) than in any of the other species.

Body 9–10 mm., wing 9·5–10 mm., cerci 10–11 mm.

♀. Head brown with darker markings. Eyes black, ocelli black with whitish apices. Prothorax fulvous brown, anterior margin with a thin dark line and a faint dark patch on either side of median line. Mesothorax pale brown

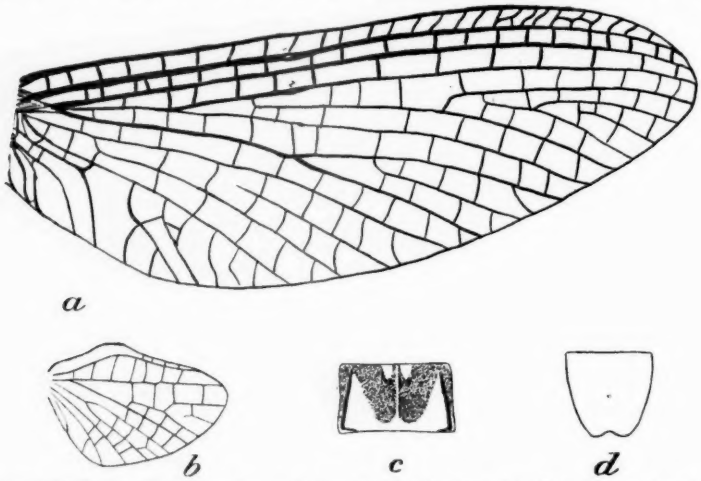


FIG. 27.—*Aprionyx intermedius* n. sp. *a*, *b*, fore- and hind-wings of ♀ subimago; *c*, dorsal view of abdominal segment of subimago; *d*, ventral plate of ♀.

with darker markings, a dark brown horizontal stripe on lateral margin of scutum. Metathorax brown. Abdomen castaneous-brown, segments 1 and 10 dorsally uniform, segments 2–8 each with a pale spot on anterior margin on either side of the narrow medio-dorsal line, a subtriangular pale patch towards the postero-lateral corner connected along posterior margin by a pale bar on the posterior segments, and bounded laterally by a blackish streak; ventrally paler, each segment with a faint darker spot in middle of anterior margin. Legs ochraceous, femora with dark basal, middle, and apical bands. Wings greyish, longitudinal veins light red-brown, cross-veins jet black. Cerci whitish or pale grey, with narrow dark annulations. Venation of ♂ imago paler.

Egg.—Similar to that of *tabularis*, ·33 mm. long diameter.

Nymph.—Resembling the nymph of *peterseni* very closely, but the posterior margins of *all* the abdominal segments are denticulate, the denticles strong and closely set, with many minute submarginal accessory denticles; and the cerci are only sparsely setose.

Coloration in general like that of *peterseni*, but the abdominal pattern as figured for the subimago, with the brown colour more extensive and separating the two postero-lateral pale patches except on the posterior segments where they are connected by a pale bar across the posterior margin.

Locality.—Groot Drakenstein (A. C. H.).

Remarks.—Only one ♂ imago and three subimagos of this species have been obtained. It is probably not rare, but the nymphs very closely resemble those of *peterseni* and can only be discriminated by close scrutiny of the cerci and the colour pattern on abdomen. It is probably a winter and early spring fly, as those obtained were caught or bred in October. One ♂ nymph was obtained in December, and is ready to disclose the subimago.

The subimago fly is distinguished from *peterseni* by the more numerous cross-veins in the costal area, both before and after the bulla, and the tendency of the pterostigmal veins to branch and anastomose, though this is not nearly so pronounced as in *tabularis*; the abdominal pattern, and the shallowly incised ventral plate of the ♀.

Aprionyx rubicundus n. sp.

? Lestage, 1924A, p. 330 (*Atalophlebia* sp. subimago Paarl).

Imago.—♂. 8–9 cross-veins before bulla, 8–10 simple, mostly straight, oblique cross-veins in pterostigmal area. Hind-wing with Sc extending nearly $\frac{9}{10}$ length of wing, five cross-veins in subcostal area, other cross-veins considerably reduced. Penis with short apical cleft, the lobes adnate.

Body 7 mm., wing (6·75) 7–8 mm., cerci broken.

Turbinate eyes black basally, yellow or fulvous on top. Prothorax brown, darker in centre, with black lateral margin. Mesothorax deep red-castaneous or maroon, uniform, laterally brown with whitish oblique marks from base of hind-wing, and a horizontal white mark extending from base of fore-wing forwards; ventrally brown. Metathorax brown. Abdomen mottled pale and sepia-brown, segment 1 nearly uniform, segments 2–8 as figured, segment 9 nearly and segment 10 completely uniform brown. Legs ochraceous, femora with basal, middle, and apical bands.

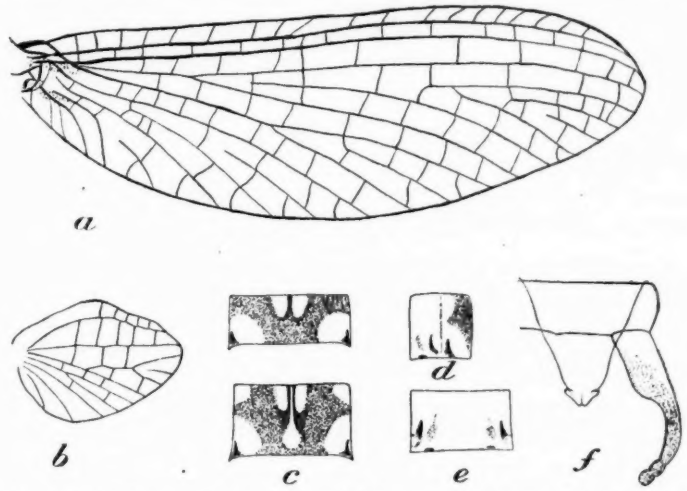


FIG. 28.—*Aprionyx rubicundus* n. sp. *a*, *b*, fore- and hind-wings of ♂ imago; *c*, dorsal view of abdominal segments 2 and 6; *d*, lateral view of abdominal segment (dorsum to right); *e*, ventral view of abdominal segment; *f*, ventral view of forceps and penis of ♂.

Cerci ochraceous with narrow dark annulations. Wings clear, a little cloudy in costal and subcostal areas, neuration bright ochraceous-brown, both longitudinal and cross-veins equally coloured.

Localities.—Montagu (October 1919, K. H. B.); River Zonder End Mts. (December 1920, K. H. B.); Banhoek, Stellenbosch (October 1929, K. H. B.); Nonna Kloof, Keeromberg, Worcester (September 1930, K. H. B.).

Remarks.—Only the fly of this very pretty species is known. It is a small species with distinctive maroon mesothorax and bright brown neuration.

Aprionyx pellucidulus (E.-P.).

Esben-Petersen, 1920, p. 499, figs. 1, 2; Lestage, 1924A, p. 330.

Imago.—6–8 fine cross-veins before bulla, 10–12 fine oblique, slightly curved, not anastomosing cross-veins in pterostigmal area. Hind wing with Sc extending about $\frac{1}{2}$ length of wing, 6–7 cross-veins in subcostal area. Penis ventrally angular as in *peterseni*, but broader and blunter when viewed from below. 10th sternite with very shallow median emargination.

Body ♂ 10–12 mm., ♀ 12–13 mm.; wing ♂ 11–13 mm., ♀ 13–14 mm.; cerci 23–29 mm.

♂. Head dark brown. Turbinate eyes dark at base, paler on top, ocelli with pale apices. Pro- and mesothorax fulvous or pale castaneous, the latter with paler streaks laterally, scutellum pale. Metathorax pale brown. Abdomen pale, pellucid, segments 9 and 10 grey, segments 1–8 with dark brown transverse bar on posterior margin, some segments also show an indistinct transverse suffusion near the anterior margin, ventrally pale. Legs pale grey, femora with dark middle and apical bands, and often an indistinct suffusion near base. Cerci pale grey, the articulations slightly and indistinctly darker. Wings clear, very faintly yellowish in pterostigmal area, neuration dark brown or castaneous. Subimago similar but duller, wing membrane grey.

Egg.—(Extracted from dried subimago) similar to that of *tabularis*, ·4 mm. long diameter.

Localities.—Gt. Winterhoek Mts., Tulbagh Distr. (November 1916, R. M. Lightfoot and K. H. B.); North slopes of Matroosberg, Ceres Div. (November 1917, R. M. Lightfoot).

Remarks.—This fly has only been found in two localities, both at an altitude of about 4000 feet, and would seem to be a strictly mountain form.

The nymph is unknown, but the abdominal colour pattern of the nymph described below from the Zwartberg Pass is not very inconsistent with the adult pattern. If this be the nymph of *pellucidulus*, then the species is rightly included in the genus *Aprionyx*.

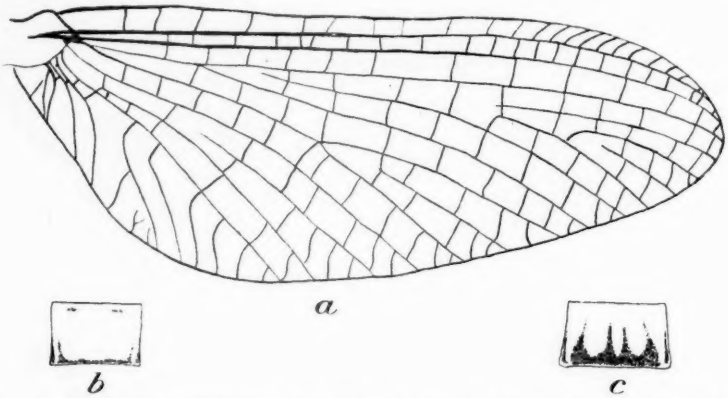


FIG. 29.—*Aprionyx pellucidulus* (E.-P.). *a*, fore-wing of topotype ♂ imago; *b*, dorsal view of abdominal segment; *c*, dorsal view of abdominal segment of nymph from Zwartberg Pass for comparison, but not definitely assigned to *pellucidulus*.

In Esben-Petersen's description (1920, p. 500) the statement that the pterostigmal cross-veins anastomose is apparently due to a transposition either in the MSS. or in the printing thereof. None of the type specimens or several others in the S.A. Museum have anastomosing cross-veins. The three ♂♂ from Ceres (Ceres *village*. Leg. Lightfoot, April 1913) are in fact the three described lower down on the same page by Esben-Petersen as *tabularis*, and later named *phoeocera* by Lestage.

Aprionyx natalica (Lestage).

? Esben-Petersen, 1913, p. 179 (*tabularis* non Eaton); Lestage, 1924A, p. 325.

Imago.—6–7 fine cross-veins before bulla, 9–10 oblique, curved not anastomosing cross-veins in pterostigmal area. Hind-wing with Sc extending almost to apex of wing, 5–6 cross-veins in subcostal area.

Body 11–12 mm.; wing ♂ 11–12 mm., ♀ 13–14 mm.

♂. Blackish (in sicco), abdomen lost. Legs fulvous, front femur blackish, mid and hind femora with blackish apices. Neuration fulvous brown, pterostigmal area suffused yellowish.

Locality.—Krantzkop, Natal (November 1917, K. H. B.); Katberg and Hogsback (Albany Mus.).

Remarks.—The nymph being unknown, it can only be assumed that this is a species of *Aprionyx*. For further description of the fly see Lestage.

The Zululand specimen referred to by Esben-Petersen in 1913 is not in the South African Museum collection.

Aprionyx sp. Nymph.

Some nymphs collected on the Zwartberg Pass (November 1929, K. H. B.) are 8–9 mm. in length. The head and thorax are greyish-brown mottled, the abdomen pale yellowish, with dark transverse bars on the posterior margins of the segments (fig. 29, *c*) with four narrow streaks or lines extending forwards; a dark spot on the pleurum; segment 9 nearly uniform; segment 10 pale. Femora with three dark bands. Cerci pale, uniform. Gills resembling those of *peterseni* in shape.

As remarked above, this may possibly prove to be the nymph of *pellucidulus*, and therefore no name is attached to this form.

Gen. *Adenophlebia* Eaton.

Eaton, 1884, p. 111; Ulmer, 1920, p. 115; Lestage, 1924A, p. 332, and p. 336 (*Esbenophlebia*).

Imago.—Like *Aprionyx* as regards tarsal claws, fore-wings, and 10th sternite of ♂. Hind-wing with costal margin strongly and angularly convex, Sc short, costal area short and broad, subcostal area narrower than costal area. Genital styles of ♂ obscurely 3-jointed, *i.e.* there is only one clearly demarcated terminal short joint, basal joint more or less abruptly narrowed in distal half; penis single, broad basally, rapidly tapering, apically cleft for a short distance, the lobes slightly dehiscent, each with a recurved spiniform process ventrally. Ventral plate of ♀ apically truncate.

Egg.—Ovoid, sculptured with small pits, no attachment threads.

Nymph.—Antennae long. Labrum shallowly emarginate, with 4–5 denticles. Hypopharynx with forwardly

curved lateral processes on median lobe. Labium with inner lobes horizontal, *i.e.* on the same plane as outer lobes, with fine setae only, palp rather slender, 3rd joint conical, longer than broad. Shoulder of prothorax with a patch of short stout spines. Tarsal claws denticulate, the denticles increasing regularly in size distally. Abdominal segments 8 and 9 with only one acute point at postero-lateral corner. Gills double, ovate-lanceolate, tapering to a fine point.

Remarks.—Besides the three South African species herein mentioned, Navas (1929) has described *A. burgeoni* from the Belgian Congo. *A. ornata* Ulmer, 1916, from the Cameroons, has been placed in a separate genus: *Adenophlebioides* Ulmer, 1924, as it differs in venation, though it has the tarsal claws alike.

In explanation of the sinking of *Esbenophlebia* as a synonym it may be noted: firstly, that Eaton's figure of *dislocans* shows a very asymmetrical fork of MA, which is surely not normal, even if correctly drawn; secondly, Esben-Petersen's statement (1913) that the neuration of *westermanni* agrees with that of the type species is, from the figure he gives, obviously incorrect, as pointed out by Lestage, 1917.

Lestage therefore (1924), without, however, seeing any actual specimens, instituted the genus *Esbenophlebia* for *westermanni*, defining it from Esben-Petersen's figure as follows: $1R_2$ arising separately from Rs, $1R_{2b}$ connected with Rs, junction of R_{4+5} with Rs nearer to junction of Rs and MA than to fork of MA, only a single cross-vein on either side of 1MA, connecting this vein with MA_1 and MA_2, cross-veins between MA (and MA_2) and M_{1+2} few (4–5).

Of the numerous examples examined by me not one has been found showing these peculiarities, though reduction of the cross-veins in MA to two or occasionally to one on one side or the other may occur. Moreover, not one of three specimens in the S.A. Museum labelled by Esben-Petersen himself as *westermanni* shows the very narrow wing form or the peculiar neuration.

Both Eaton's and Esben-Petersen's figures are therefore to be regarded as representing abnormal wings, and Lestage's genus falls as a synonym of *Adenophlebia*.

The three species *auriculata*, *peringueyella*, and *dislocans* are very closely allied, and it is difficult to find constant differential characters. In the fore-wing the best criteria seem to be the number of cross-veins on either side of MA, *i.e.* between R_{4+5} and MA_1 and between MA_2 and M_{1+2}, and the cross-veins between Cu_1 and the first cubital intercalary. The ♂ genitalia do not differ. The partial or complete demarcation of two small apical joints in the forceps is so inconstant as to be valueless for specific differentiation.

In order to try and obtain as true a picture as possible of the species, Mr. Harrison and I have analysed all the specimens in hand, counting both wings of each specimen, and taking the average. The extreme figures are given in brackets on either side of the average number in the following table, but in the descriptions only the averages are given.

	auriculata.	*peringueyella.*		*dislocans.*	
	Barberton and Natal.	♂.	♀.	♂.	♀.
a. C. v. in costal area before bulla	6–7	6–7	(6) 7 (8)	(5) 6 (8)	(6) 7 (9)
b. ,, ,, ,, after ,,	11–12	(11) 14 (17)	(12) 14 (17)	(10) 11 (14)	(14) 15 (16)
c. ,, subcostal area	15–16	(15) 16 (18)	(16) 17 (19)	(12) 14 (17)	(14) 16 (20)
d. ,, subradial area	11 (16)	(11) 12 (14)	(12) 13 (14)	(8) 9 (12)	(9) 10 (11)
e. C. v. between R_{4+5} and MA_1	9–11	(9) 12 (13)	(11) 12 (14)	(5) 7 (8)	(7) 8 (10)
f. ,, ,, MA_2 and M_{1+2}	10–11	(9) 10 (12)	(8) 11 (13)	(4) 6 (8)	(6) 8 (10)
g. ,, ,, M_{3+4} and Cu_1	3–4	(3) 4 (5)	(4) 5 (7)	(2) 3 (4)	(3) 5 (6)
h. ,, ,, Cu_1 and 1st ICu_1	2–3	(2) 3 (5)	(3) 4 (5)	(0) 2 (3)	(2) 3 (3)

Thus it will be seen that taking characters *d*, *e*, *f*, *h*, together with the extent of the wing markings, the species are well characterised, especially *dislocans*; though in the case of some individual specimens it might be difficult to identify them satisfactorily on venational characters alone.

The differences in numbers of cross-veins are not always due to variation in size, in particular those in *d*, *e*, *f*, and, moreover, they are greater between species than between the two sexes or between large and small specimens of the same species. This is particularly noticeable between the two markedly spotted species *peringueyella* and *dislocans*, and between the latter and *auriculata*. Between *peringueyella* and *auriculata* the difference is not so noticeable, but our conception of the latter species is as yet based on only four specimens (excluding Eaton's material).

The ♀♀ appear always to have the wings more heavily spotted than the ♂♂, though there is not such a marked difference as Eaton recorded between the ♀ and ♂ of *dislocans*. For this reason I had doubts whether Eaton was correct in regarding his *auriculata* ♂ as conspecific with Walker's *dislocans* ♀. This was confirmed by a tracing of Walker's type ♀, for which I thank Mr. D. E. Kimmins of the British Museum. There is no difference between *westermanni* and *dislocans*.

It is impossible to institute any comparison of *burgeoni* Navas with the South African species, as it was founded on a single subimago, sex not stated, inadequately described, and only the portion of the fore-wing proximal to MA figured.

Adenophlebia auriculata Eaton.

Eaton, 1884, p. 112, pl. xiii, fig. 21; Esben-Petersen, 1913, p. 180 (*dislocans* non Wlkr.).

One ♂ imago and 1 ♂ subimago (Barberton, March 1911), seen and recorded by Esben-Petersen, have been removed from their mounts and examined. Both show a perfectly symmetrical fork of MA. In the area between MA and Rs–R_{4+5} there are 9 (imago) and 11 (subimago) cross-veins; in the area between MA and M_{1+2} there are 10 and 11 respectively. Costal cross-veins before bulla 6–7, beyond bulla 11–12; subcostal 15–16; subradial 11; between Cu_1 and first $1Cu_1$ 2. Thus corresponding closely with Eaton's figure, which represents the ♂ originally described as *auriculata* from Grahamstown, in which the numbers are respectively: 11, 11, 6, 12, 17 (18), 16,* 3.

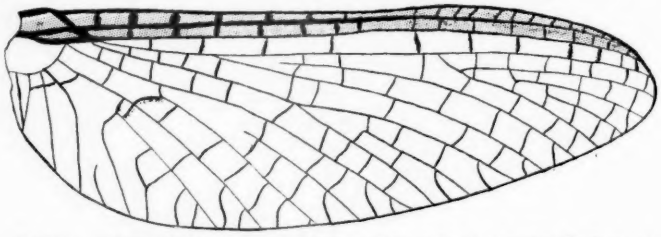


FIG. 30.—*Adenophlebia auriculata* Eaton. Fore-wing of ♂ imago (Barberton).

Walker's type ♀ was from the Cape but without definite locality. From the similarity of the *hind*-wings Eaton considered his ♂ conspecific with Walker's ♀. According to Eaton the ♂ has clear wings, but the ♀ has various dark spots on the cross-veins, and a dark spot at base of costa (between root of wing and cross-vein immediately beyond the humeral brace vein).

The Barberton ♂ imago has small reddish-brown spots around the cross-veins in costal and subcostal areas (before the bulla), and slight thickenings of the cross-veins between R_1 and Rs; in fact all the cross-veins in base of wing are feebly thickened with reddish-brown colour.

A ♂ from Natal (S. G. Rich, Natal Mus.) is similar, but has sixteen cross-veins in the subradial area, as in Eaton's specimen. I have seen another specimen from Grahamstown (Albany Mus.), which is the type locality for Eaton's species.

Adenophlebia sp. Nymph.

Some nymphs collected on the Zwartberg Pass (Prince Albert) in November 1929 (K. H. B.) resemble structurally the nymphs described below except that the inner lamellae of the gills are only half the length of the outer lamellae.

The coloration, however, is notably different. The whole body is pale uniform (or almost so) ochraceous or straw-colour. The small black spot at base of wing-cases (representing the humeral brace vein of the imago) is

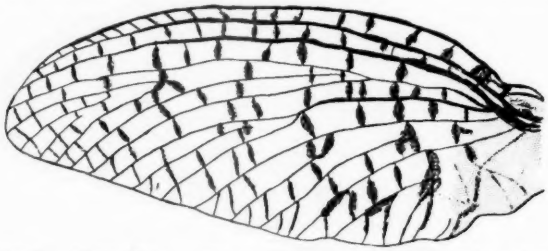


FIG. 31.—*Adenophlebia ? auriculata* Eaton. Fore-wing dissected out of nymph ready to disclose subimago (Zwartberg Pass).

consequently more conspicuous. Femora faintly banded. Abdominal segments with dark brown narrow border on posterior margins, except segment 10, which is uniformly pale.

Size 9–13 mm. The largest nymph was ready to disclose the subimago, and one wing was dissected out. As the number of cross-veins in the critical areas seems to coincide best with that of *auriculata*, these specimens are provisionally assigned to this species.

Adenophlebia peringueyella Lest.

Lestage, 1924A, p. 333 (incl. *dislocans* non Walker).

Imago.—Front tibia slightly longer than femur, tarsus subequal to tibia, its joints decreasing in length distally. Ventral plate of ♀ apically truncate or very feebly excavate. Genital styles of ♂ and penis as in Eaton's figure of

* Sixteen cross-veins in the subradial seems abnormally high, but it occurs in the Natal specimen.

dislocans, penis apically bifid, each lobe with a recurved spiniform process ventrally. Cross-veins before bulla 6–8, beyond bulla 12–14, subcostal 16–18, subradial 11–13, between R_{4+5} and MA_1 10–12, between MA_2 and M_{1+2} 10–13, between Cu_1 and 1st ICu_1 4 (not counting proximal connecting vein or oblique vein to margin).

Body ♂ 10 mm., ♀ 11–12 mm.; wing ♂ 10 mm., ♀ 11–13 mm.; cerci 15–18 mm.

♀. Head pale ochraceous, a dark brown bar between ocelli, a dark spot on either side of median line near posterior margin. Eyes black, ocelli dark, apices paler. Prothorax pale ochraceous medianly, more sepia laterally. Meso

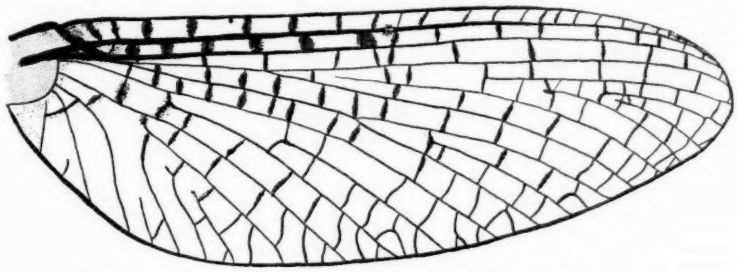


FIG. 32.—*Adenophlebia peringueyella* Lest. Fore-wing of ♀ imago.

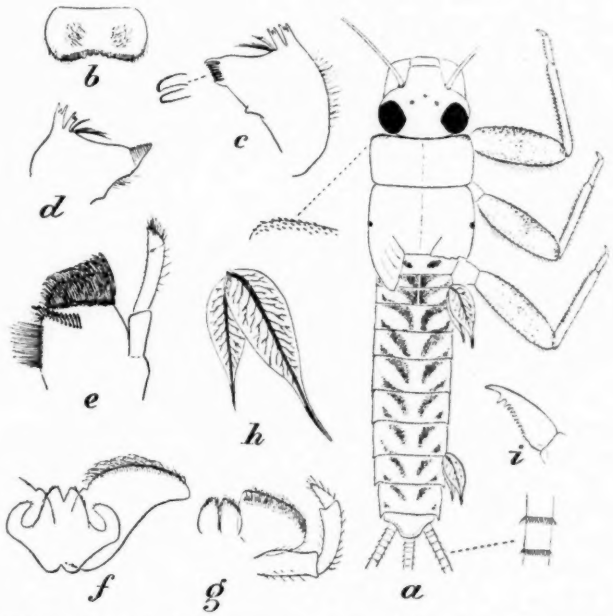


FIG. 33.—*Adenophlebia peringueyella* Lest. *a*, nymph, with shoulder of prothorax and portion of cercus further enlarged, right wingcase cut away, and gills 2–6 omitted; *b*, labrum; *c*, *d*, left and right mandibles; *e*, maxilla; *f*, hypopharynx; *g*, labium; *h*, gill; *i*, claw.

thorax dorsally warm brown, including scutellum, scutum antero-laterally with pale border, laterally with darker and lighter brown, the area occupied by the decurrent portion of the membrane of fore-wing white. Metathorax brown with paler transverse bar on either side of median line. Abdominal segments 1 and 2 brown with narrow pale medio-dorsal line and a transverse pale bar or oval patch dorso-laterally; segments 3–9 pale brown, each with a dark brown oblique bar running from near middle line posteriorly to the antero-lateral corner, the lateral margin also dark (the difference between the coloration of the first two segments and the others is more verbal than real; in

the former the dark colour occupies the greater area, in the latter the pale colour. *Cf.* also Eaton's description of *dislocans* ♀). Segment 10 pale brown. Abdomen ventrally pale greyish. Legs ochraceous or fulvous, femora with dark median bands, knees also slightly darker. Cerci brown, uniform. Neuration dark sepia-brown, pterostigmal area somewhat milky (direct light) or ochraceous (transmitted light), the ante-humeral costal area and its decurrent membrane white, the humeral brace vein, however, suffused, spots dark sepia, usually oval, confined to the immediate vicinity of the cross-veins, never diffuse or forming fasciae. Hind-wing clear, except for a large blotch at base.

♂ similar but darker, mesothorax dorsally Vandyke brown; turbinate eyes pinkish (in alc.). There is very little difference in the number or size of the spots or enlargements of the cross-veins.

Subimago.—Similar but paler, especially dorsum of mesothorax, wing membrane grey.

Egg.—Bluntly oval, ·2 mm. long diameter, closely pitted, no attachment threads.

Nymph.—Legs moderately slender, femora with short pointed spines on front and hind margins and on upper surface, hind margin with setae as well, tibiae and tarsi spinose on inner margin, sparsely setose on outer margin; claws slender, denticulate, about 12–16 denticles, increasing regularly in size distally.

Up to 13–14 mm., cerci about as long as body.

Mottled brown, usually an oblong dark patch between the lateral ocelli, eyes black. Metathorax pale with two transverse oval dark spots. A small dark spot at base of wing-case near outer margin, corresponding with the dark humeral brace vein in imago. Legs pale ochraceous, femora with suffused patch on front margin expanding into a median band on both upper and lower surfaces, with a roundish sepia spot in the band on lower hind margin, knees dark. Abdomen pale ochraceous with dark markings as figured, segment 10 uniform, ventrally pale, uniform. Cerci ochraceous, uniform.

Localities.—Paarl (Rev. G. Hawke); Groot Drakenstein (A. C. H.); Jonkershoek, Stellenbosch (A. C. H.); Table Mt. slopes (K. H. B.).

Habits.—The "September Brown" is a very notable winter and spring May-fly, occurring from mid-June to early October. Emergence of the subimago takes place by day, after the nymph has crawled out of water on to a stone; but emergence can take place from the surface film of the water. The subimagos are very sluggish and can easily be caught with the hand. The subimaginal stage lasts 1½–2½ days, and the imago has been kept in captivity for 10–11 days (A. C. H.).

Half-grown nymphs begin to be conspicuous in running streams in March. Early attempts to breed them in captivity were not too successful, but later they were found to thrive on Lakeside ooze (see p. 203). A batch of nymphs observed during April and May (½–¾ grown) moulted regularly every fortnight (A. C. H.).

Nymphs with similar coloration from between Graskop and Sabi, Transvaal, were obtained by J. C. Dendy in July 1930, but whether they belong to this species or to *westermanni* is impossible to tell.

Adenophlebia dislocans (Wlkr.).

Esben-Petersen, 1913, p. 180, fig. 1 (*westermanni*, abnormal wing); Lestage, 1917, p. 91, and 1924A, p. 338 (*Esbenophlebia w.*).

Imago.—Like *peringueyella*, but with the following numbers of cross-veins: before bulla 5–6, beyond bulla 11–13, subcostal 16, subradial (7) 8, 9, 10–12, between R_{4+5} and MA_1 6–7 (8), between MA_2 and M_{1+2} (5) 6–7 (8), between Cu_1 and 1st $1Cu_1$ 1 or 0. That is to say, there are noticeably fewer cross-veins in the MA, M, and Cu areas. Summit of costal projection nearer middle of wing than in *peringueyella*.

Smaller than *peringueyella*: body ♂ 6–8·5 mm., ♀ 10 mm.; wing ♂ 6·5–9 mm., ♀ 10·5 mm.; cerci 16–20 mm.

Colour as in *peringueyella*, but the wings marked with heavier and warmer brown blotches and spots, which are diffuse and tend to form fasciae. Hind-wing spotted.

Egg.—As in *peringueyella*.

Nymph.—Not distinguishable from that of *peringueyella*, except that there are *usually* only four denticles in the labral emargination, and the size is smaller: 10–11 mm.

Localities.—Groot Drakenstein (A. C. H.); Jonkershoek, Stellenbosch (A. C. H.); North slopes of Matroosberg, Ceres Div. (November 1917, R. M. Lightfoot); Montagu (October 1919, K. H. B.); Langeberg Mts., at Riversdale (October 1926, K. H. B.); Schuurfteberg Mts., east of Citrusdal (February 1928, K. H. B.); River Zonder End Mts. (November–December 1928, K. H. B.); Table Mt. slopes (March 1931, K. H. B.); Keurbooms River, Knysna Distr. (December 1930, January 1931, K. H. B.).

Habits.—The "Summer Brown" is also a notable fly in the Cape, emerging in October or November after the disappearance of the "September Brown," and continuing throughout the summer until March. It is a smaller fly and more heavily blotched and spotted.

There is some variation in the blotching, but the blotches at base of the median and cubital intercalaries, and at the cross-vein connecting M_{3+4} with M_{1+2} and Cu_1 are always large and well marked. The ♀ is, as a rule, more heavily spotted than the ♂.

The subimago emerges by day, the nymph crawling up a stone, either half out or completely out of the water. The imago follows in about 24 hours, and specimens have been kept in captivity 6½ days (A. C. H.).

The ♂ is remarkably active in hot sunshine; when pursued it takes short quick flights from stone to stone, and when it settles it faces the pursuer; when it settles on bushes it has the habit of many grasshoppers of sidling round the stem to keep out of sight (K. H. B.).

The nymphs are indistinguishable from those of the "September Brown" in structure and coloration.

Castanophlebia n. g.

Imago.—Claws dissimilar, one hook-like, the other obtuse. Fore-wing long and narrow; fork of MA rather broad but symmetrical or almost so; M symmetrically and narrowly forked; Cu_2 and 1A at base separate, sub-

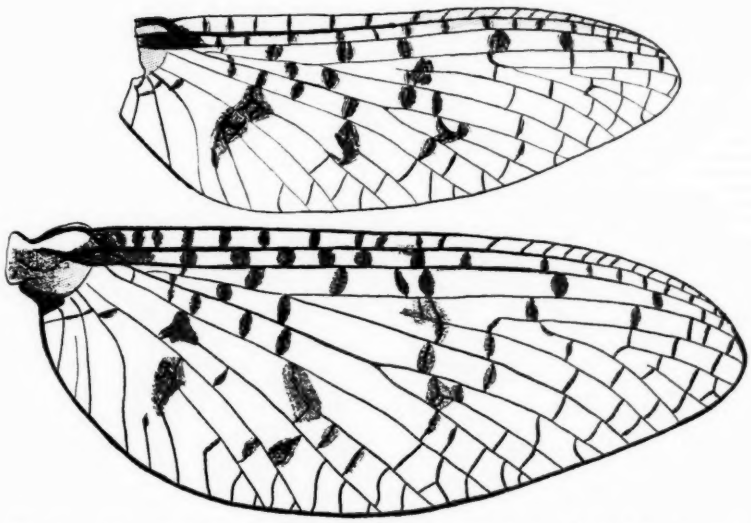


FIG. 34.—*Adenophlebia dislocans* (Wlkr.). Fore-wing of ♂ above and of ♀ below, imagos.

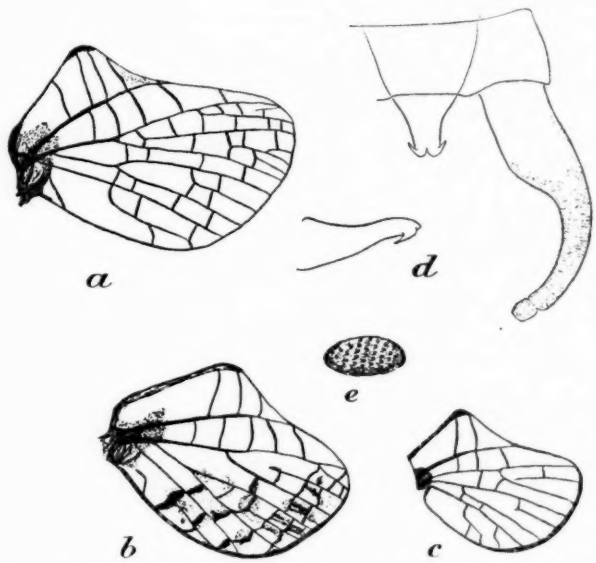


FIG. 35.—Hind-wings of : *a*, *Adenophlebia peringueyella* ; *b*, *westermanni* ; *c*, *dislocans* ; *d*, forceps and penis of ♂, with lateral view of penis (all three species) ; *e*, egg of *peringueyella*.

parallel. Hind-wing with angular process on costal margin, summit of the arch beyond middle of wing; Sc rather long, costal area narrow, subcostal area broader than costal; MA simple. Genital styles of ♂ 3-jointed; penis broad, deeply cleft, lobes divergent, with pointed outwardly directed processes in middle of ventral surface. 10th sternite of ♂ undivided. Ventral plate of ♀ sharply incised.

Nymph.—Legs slender. Claws denticulate, a large tooth in middle of inner margin preceded and followed by smaller denticles. Shoulder of prothorax with a single row of a few setae. Antennae long. Labrum incised. Hypopharynx without lateral processes on median lobe. Mandibles as in *Aprionyx*, prostheca distinct but slender. Maxilla with a row of pectinate spines arising from very large sockets. Inner lobes of labium ovate, in same plane as outer, palp rather slender, 3rd joint narrow cylindrical. Abdominal segments 8 and 9 postero-laterally uniaculeate. Gills seven pairs, double, slender and very narrowly lanceolate, tracheae unbranched.

Remarks.—Allied to *Deleatidium* and still more closely to *Atalophlebioides*, but differing in the broad, characteristic forking of MA and the long stalk of MA in the fore-wing of adult, and the very narrow, almost thread-like gills of the nymph.

Castanophlebia calida n. sp.

Imago.—4–6 cross-veins before bulla, 9–11 in pterostigmal area, the latter oblique, straight or slightly sigmoid, rarely anastomosing; subcostal 12–14; between R_{4+5} and MA_1 7–8; between MA_2 and M_{1+2} 6–7; 1–3 cross-veins between 1MA and MA_1 and MA_2 (not counting proximal connecting veins); $1R_{3b}$ usually not connected with Rs. Ventral plate of ♀ sharply incised. Genital styles of ♂ with distal two joints very short; penis broad, bilobed, lobes

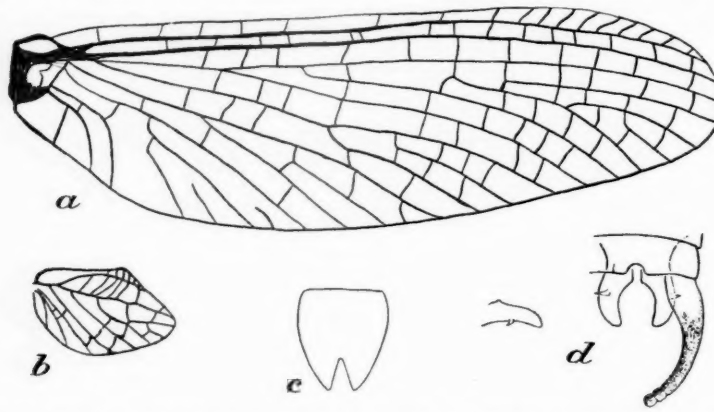


FIG. 33.—*Castanophlebia calida* n. g., n. sp. *a*, *b*, fore- and hind-wings of imago; *c*, ventral plate of ♀; *d*, ventral view of forceps and penis of ♂, with lateral view of penis.

divergent, each lobe apically blunt, with a small acute process ventrally in the middle. 10th sternite of ♂ with a median semi-circular excision. Median cercus slightly longer than the lateral ones.

Body: ♂ 6·5 mm., ♀ 6–9 mm.; wing ♂ 7 mm., ♀ 6·5–9 mm.; cerci 8–10 mm.

Castaneous, nearly uniform, occiput paler; a dark brown horizontal bar on lateral margin of scutum from above insertion of fore-wing; abdomen paler ventrally. Eyes black, apices of ocelli whitish. Legs fulvous. Cerci fulvous, uniform. Neuration fulvous, castaneous, costal and subcostal areas in the pterostigmal region semi-opaque (♂ and ♀).

Subimago.—Similar but paler, more fulvous, mesothorax dorsally with a darker median patch in front and longitudinal dark stripe laterally. Legs pale fulvous, knees darker. Cerci pale greyish, uniform.

Egg.—Oblong-oval, twice as long as broad, ·25 mm. long diameter, pale yellow, surface not sculptured, no attachment threads.

Nymph.—Abdominal segments postero-laterally quadrate, or only slightly acuminate. Denticles on posterior margins very minute except on segment 10. Mouth-parts as figured; outer margin of mandible strongly convex, very sparsely setose; inner lobes of labium with fine setae only. Legs slender, femora with scattered short blunt spines on both margins and upper surface, setae on hind margin, tibiae and tarsi with setae on outer margin and acute spines on inner margin. Claws with a strong tooth in middle, with four (usually) strong outstanding denticles distal to it, and four smaller, forwardly directed denticles proximal to it. Cerci elongate, the median slightly the longer. Gills 1–6 bifurcate, 7th gill with a much smaller inner branch, which is often only a rudiment or even absent.

Up to 8 mm., antennae 3–4 mm., cerci 8–10 mm.

Fulvous, rufous, or castaneous, slightly mottled on pro- and meso-thorax dorsally. Abdomen with a faint darker, slightly oblique stripe on either side of each segment, though usually obsolete on the posterior segments. Ventrally paler, usually with three round median spots, one between bases of front legs, one between bases of middle legs, and one immediately behind the latter. Legs ochraceous, knees and tarsi darker. Cerci fulvous, uniform.

Gills whitish, tracheae black. Young nymphs are paler brown and the hind margins of the posterior abdominal segments are pale. Only mature nymphs show the characteristic rufous or deep castaneous coloration.

Localities.—Groot Drakenstein (A. C. H.); Jonkershoek, Stellenbosch (A. C. H.); Banhoek, Stellenbosch (K. H. B.); River Zonder End Mts. (January 1919 and November–December 1928, K. H. B.); Witte River, Wellington Mts. (November 1922, K. H. B.); Table Mt. slopes (October 1913 and March–April 1931, K. H. B.); French Hoek (April 1931, K. H. B.); Zwartberg Pass, Prince Albert (November 1929, K. H. B.); Hex River, Worcester (A. C. H.); Genadendal (K. H. B.); Elgin (K. H. B.).

I have also seen some nymphs from Sabi, Transvaal (July 1930, J. C. Dendy), which are indistinguishable from Cape specimens, but the locality should be quoted with a query until the adults are obtained.

Habits.—The "Chestnut Dun" is notably a *day* fly. The subimagos emerge by day on protruding stones, often in great numbers, from early October onwards throughout the summer; but the numbers decrease towards February and March. The imago emerges about 24 hours later.

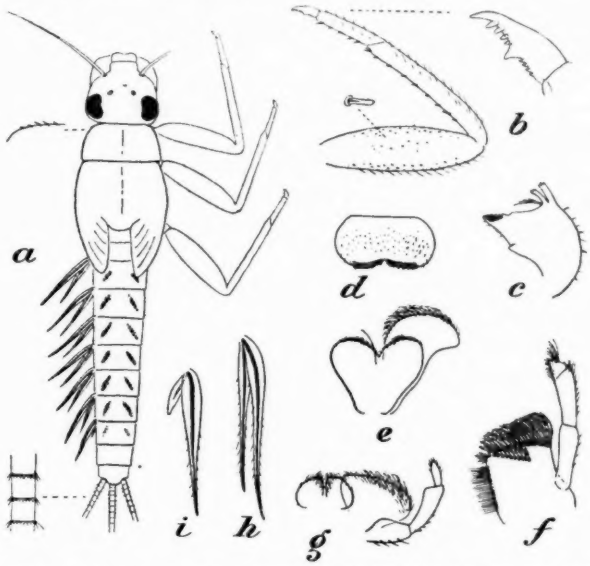


FIG. 37.—*Castanophlebia calida* n. g., n. sp. *a*, nymph, with shoulder of prothorax and portion of cercus further enlarged; *b*, leg, with claw further enlarged; *c*, mandible; *d*, labrum; *e*, hypopharynx; *f*, maxilla; *g*, labium; *h*, *i*, 2nd and 7th gills.

Females have been observed ovipositing in October (A. C. H.) and early April (K. H. B.). They do not dip and rise at once like the "April Dun," but rest on the surface for a second or two.

Small half-grown nymphs are found in June, and in large numbers up to December, after which they become less plentiful. The nymphs frequent swift-running streams, and are evidently able to hold their own in torrential waters. They are often found crawling on the rock at the very lip of the small waterfalls found in mountain streams (K. H. B.).

In a tank of still water they thrive for a time on "Lakeside ooze" (p. 203), but are difficult to rear to the subimago stage unless captured when almost full-grown (A. C. H.).

Gen. *Choroterpes* Eaton.

Eaton, 1884, p. 104; Ulmer, 1920, p. 116; Lestage, 1921, p. 228 (nymph.)

Imago.—Tarsal claws dissimilar, one acute, hook-like, the other obtuse. Fore-wing with the costal margin slightly but distinctly concave in the middle; Cu_2 and 1A at base separate, subparallel. Hind-wing with costal margin strongly and obtusely angulate, with a slight concavity at end of Sc, which is short; costal and subcostal areas subequal in width; MA simple. 10th sternite of ♂ undivided. Ventral plate of ♀ shallowly incised apically. Genital styles of ♂ 4-jointed, 1st joint ring-shaped, short, sometimes obscurely demarcated, 2nd long, 3rd and 4th short. Penis rather narrow, divided into two long adnate lobes, without appendices. Cerci 3.

Nymph.—Eyes lateral. Antennae short. Labrum deeply incised. Mandibles with prostheca. Labium with inner lobes narrow, with stout spinules, palp slender, 3rd joint cylindrical, nearly as long as 2nd. Hypopharynx with forwardly curving lateral processes on median lobe. Shoulder of prothorax with a single row of slender spines.

Legs moderately stout, claws denticulate, the denticles increasing in size distally. Abdominal segments 8 and 9 postero-laterally uniaculeate. Cerci 3, elongate. Gills 7; 1st single, narrow-lanceolate, 2nd–7th double, foliaceous, the distal half considerably narrower than the basal half and arising from an indentation, tracheae branched.

Remarks.—This genus has been known hitherto from Europe, North and Central America, and Lower Burma, The discovery of an African representative is due to Mr. A. C. Harrison.

Choroterpes nigrescens n. sp.

Imago.—In fore-wing 1–3 cross-veins before the bulla, usually faint; numerous simple, straight or sometimes slightly sigmoid cross-veins in pterostigmal area; subcostal 16–19, subradial 10–12, of which only 1–2 are proximal

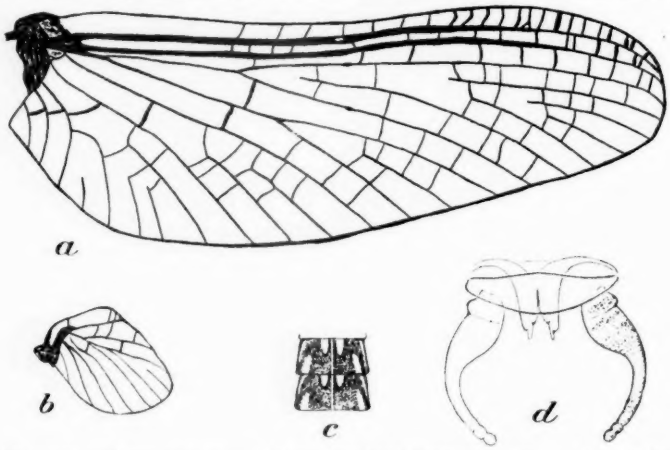


FIG. 38.—*Choroterpes nigrescens* n. sp. *a*, *b*, fore- and hind-wings of imago; *c*, abdominal pattern of nymph; *d*, forceps and penis of ♂.

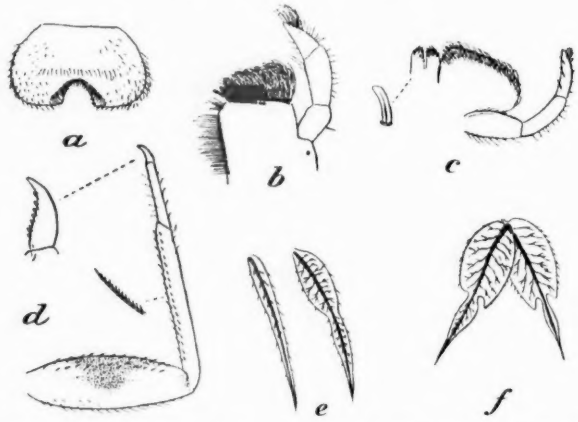


FIG. 39.—*Choroterpes nigrescens* n. sp. nymph. *a*, labrum; *b*, maxilla; *c*, labium; *d*, leg, with claw further enlarged; *e*, two forms of 1st gill; *f*, one of the following gills.

to bulla. Hind-wing with few cross-veins; 3–4 in subcostal area, 1–2 in subradial. Genital styles of ♂ with basal ring-like joint obscurely demarcated from 2nd, but visible by the convexity on outer margin; penis lobes as figured. Distal margin of 10th sternite of ♂ evenly convex.

Body ♂ 7–8 mm., ♀ 7–10 mm.; wing ♂ 7–8 mm., ♀ 7·5–10·5 mm.; cerci ♂ 8–9 mm., ♀ 7–10 mm.

♀. Head raw umber with darker mottling, eyes black, ocelli black at base, then with a castaneous ring, apically white. Prothorax brown with blackish margins and markings. Mesothorax dark brown dorsally, uniform, scutellum blackish; laterally with rufescent markings at the joinings. Metathorax dark brown. Abdomen dark brown, posterior margin of each segment black, a medio-dorsal pale streak bordered with black, on either side of which is a pale oval or conical spot in anterior half of segment. Posterior segments also show a faint pale streak just dorsal to the lateral margin. Sternites of thorax and abdomen pale, more or less rufescent, the contrast between dorsal and ventral surfaces of abdomen very marked. Femora with broad dark suffusion in middle and dark knees, tibiae grey, tarsi paler. Cerci brown, with narrow blackish annulations. Neuration dark brown, a gamboge patch on the pterostigmal portion of the costal and subcostal areas in the ♀ only.

♂ similar but darker, almost black on the mesothorax dorsally, turbinate eyes castaneous on top, genitalia grey or blackish.

Nymph.—Abdomen segments 4 (or 5)–9 laterally acuminate, more strongly so than in the nymph of *Euthraulus*. Labrum more deeply incised, and mandible more setose on outer margin than in *Euthraulus*.

Up to 10 mm., cerci 1¼–1¾ as long as body.

Mottled greyish or brownish or olivaceous. Eyes black. Abdominal segments with a pale lateral stripe, a pale dorso-lateral stripe, a pale medio-dorsal stripe with a pale conical spot on either side of it anteriorly; 10th segment mottled. Femora pale whitish, suffused with grey in middle and at apices. Cerci pale. Gills grey, tracheae dark brown.

Localities.—Groot Drakenstein (A. C. H.); Du Toit's Kloof, Rawsonville (A. C. H.); Potteberg, Bredasdorp Division (nymphs and imagos, A. T. Packham).

Habits.—Emergence of the subimago takes place from the surface film of the water, after dark, and the transformation to the imago occurs during the same night (under 12 hours). In the wild state swarms can be seen "dancing" in the hot sunshine in the forenoon, but judging from specimens in captivity the imagos live only one day (A. C. H.).

The season lasts from January to about end of April.

The nymphs seem to adapt themselves well to still water, and in captivity are very hardy and easy to breed (A. C. H.).

Euthraulus n. g.

Imago.—Resembling *Thraulus*, *i.e.* tarsal claws dissimilar, Cu_2 and 1A at base separate, subparallel; genital styles of ♂ 3-jointed, basal joint abruptly narrower in its distal two-thirds; penis narrow, divided into two long adnate tapering lobes. But differing in the more delicate neuration, with fewer cross-veins, especially subradially and in the branches of Rs in fore-wing and in hind-wing; and the much narrower, ovate shape of the hind-wings.

Nymph.—In general like that of *Thraulus*, but 1st gill filiform, and 2nd–7th gills with only three long processes on each lamella. Abdominal segments 8 and 9 postero-laterally uniaculeate. Shoulder of prothorax with a single row of slender spines. Antennae moderate. Labrum incised. Hypopharynx with curved lateral processes on median lobe. Labium with inner lobes narrow, cylindrical, with stout spinules, palp moderately slender, 3rd joint cylindrical, shorter than 2nd. Cerci elongate.

Euthraulus elegans n. sp.

Imago.—♀. Fore-wing with one or no cross-vein before the bulla, beyond bulla 8–12, subcostal 1–2 before bulla, beyond 6–7. Costal process of hind-wing noticeably scabrous. Genital styles and penis of ♂ as figured.

Body ♀ 6 mm.; wing 6·5 mm.; cerci 5–6 mm.

Head brown-castaneous, with darker markings, lighter on occiput. Eyes black, ocelli black, castaneous and white as in *Choroterpes*. Prothorax castaneous, with two dark brown stripes dorsally and blackish lateral margins. Mesothorax dorsally dark Vandyke brown, scutellum blackish, with a paler patch in front of it; laterally and ventrally brown-castaneous. Metathorax brown. Abdomen dorsally brown, with pale medio-dorsal streak on each segment, with faint indications of a light patch anteriorly on either side (cf. *Choroterpes*), lateral margins blackish, with a light faint mark dorso-laterally; ventrally pale yellowish. Femora pale, with dark median and apical bands, tibiae and tarsi pale. Cerci pale, narrowly annulate proximally. C, Sc, and R in fore-wing pale yellowish, other veins very pale and delicate.

Subimago.—♂ and ♀ similar.

Nymph.—Abdomen segments 6–9 shortly acuminate postero-laterally. Legs slender, inner margins of front tibiae rather thickly set with short spines, mid and hind tibiae only sparsely spinose; claws strongly dentate. 1st gill very slender, filiform; 2nd–6th gills ovate, each lamella with three elongate slender processes, the outer lamella slightly larger than the inner, with longer processes; 7th gill similar but smaller.

Up to 7 mm.; cerci 8–10 mm.

Brownish, mottled. Prothorax with two dark marks on either side of medio-dorsal line (sometimes coalesced) and dark lateral margins. Abdominal markings dorsally like those of *Choroterpes*. Legs pale whitish, femora with a grey patch in middle and another at apex. Cerci pale rufous, very faintly annulate.

Localities.—Groot Drakenstein (A. C. H.); Jonkershoek, Stellenbosch (A. C. H.); Hex River, Sandhills, Worcester Distr. (April, A. C. H.); Cedarbergen, Clanwilliam Distr. (January 1930, K. H. B.).

Habits.—This species occurs in October to January, and less abundantly up to early March or April.

Subimagos in captivity emerged mostly from the surface film, usually at night. On one occasion the imago emerged the same night (A. C. H.).

The nymphs tolerate still-water conditions well, but are not so hardy as those of *Choroterpes* (A. C. H.).

Remarks.—Some nymphs from Schuurmans Kloof and Olifants River near Satara, Transvaal (June 1930, J. C. Dendy), and also a subimago from Upington, Cape Province, in all probability belong to this species.

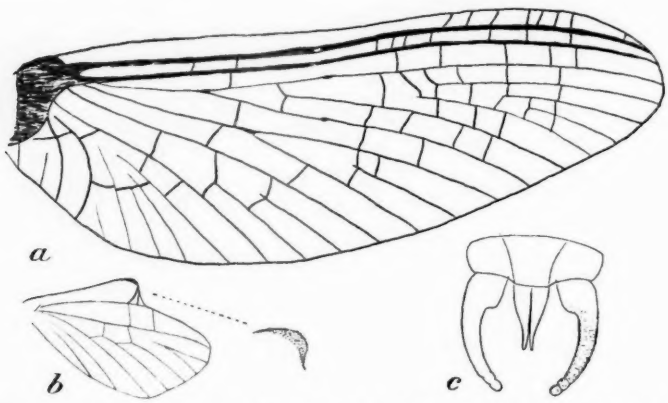


FIG. 40.—*Euthraulus elegans* n. g., n. sp. *a*, *b*, fore- and hind-wings of ♀ imago, with costal process of latter further enlarged; *c*, forceps and penis of ♂.

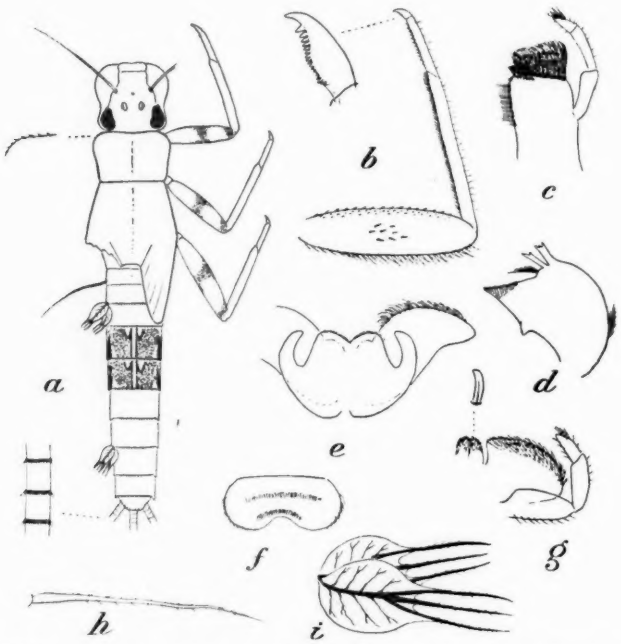


FIG. 41.—*Euthraulus elegans* n. g., n. sp. *a*, nymph, with shoulder of prothorax and portion of cercus further enlarged, left wingcase cut away, and 3rd–6th gills omitted; *b*, leg, with claw further enlarged; *c*, maxilla; *d*, mandible; *e*, hypopharynx; *f*, labrum; *g*, labium; *h*, 1st gill; *i*, one of the following gills.

Family Ephemerellidae.

Ulmer, 1920, p. 118.

Imago.—Wings hyaline, with numerous cross-veins. Fore-wing with distinct well-developed subcosta; MA forked; Cu_2 at base nearer to Cu_1 than to 1A; M_{3+4} and Cu_1 divergent, with several, usually two, large disconnected intercalaries between them; Cu_2 and 1A sharply curving back, abutting on margin near base. Hind-wing well developed, costal margin angular, costal area very narrow, subcostal area broad. Genital styles in ♂ 3-jointed, the terminal joint short; penis entire or more or less bilobed, stout or slender. Eyes in ♂ turbinate. Cerci 3.

Nymph.—Crawling, flattened type. Abdominal segments usually dorsally imbricate or with spinous processes. Antennae moderate. Upper lip feebly excavate. Mandibles rather narrowly subtriangular, prostheca distinct. Maxilla narrow, tapering apically, palp small or absent. Hypopharynx, median lobe entire, outer lobes oblong. Labium, inner lobes smaller than outer, palp 3-jointed. Femora stout, claws denticulate. Cerci 3. Gills consisting of five pairs situate on segments 3–7, or of six pairs situate on segments 1–6, inserted dorsally, lamellate, imbricate, the outer lamella of first lamellate gill elytroid, each lamella bearing on its inner surface two series of delicate imbricate tracheate lamellae; gill on the 1st segment, when present, reduced to a small 2-jointed appendage.

Remarks.—Hitherto only one genus has been recorded from Africa. A second closely allied genus is described below.

The nymph of this second genus has been discovered, and also another nymph which is considered to be that of the first-recorded genus. These nymphs necessitate an alteration in the family diagnosis. All the nymphs so far known belonging to this family have five pairs of gills situate on segments 3–7. In the South African nymphs there are five or six pairs situate on segments 2–6 or 1–6 respectively. The 7th pair has gone in all cases, but the South African nymphs seem to be less specialised than other recorded nymphs in that the 1st and 2nd pairs, or at least the 2nd pair, are still retained; the 2nd pair is well developed, but the 1st pair when present is reduced. On the other hand, the maxillary palp has completely disappeared (cf. *Ephemerella deficiens* Morg.).

Gen. *Ephemerellina* Lest.

Lestage, 1924A, p. 347.

Imago.—Fore tibia of ♂ twice as long as femur; tarsus and claws? Mid and hind tarsi ½ length of tibiae, which are subequal to femora; 5th tarsal joint longest, then 2nd, 3rd=4th, 1st shortest, claws dissimilar. In ♀ all legs with tibiae subequal to femora, tarsi about ½ length of tibiae, joints decreasing thus: 5, 2, 3, 4, 1, claws dissimilar. Forceps of ♂ 3-jointed, 3rd joint much smaller than 1st or 2nd, inner margin armed with minute papillose processes. Penis moderately slender, apically bifid. Wings as figured below for *Lithogloea*.

Nymph.—Not correlated with certainty. If nymph described below proves to be correctly assigned, its characters are similar to those of nymph of *Lithogloea*, but without any gill on 1st segment, and the prothoracic sternite is raised into two spinulose or scabrous knobs.

Remarks.—It is unfortunate that the character of the tarsal claws of the foreleg in ♂ remains unknown; in Lestage's specimen they were missing, and in the Wellington ♂ examined by me both forelegs are completely missing.

As regards the ♂ genitalia I am at a loss to understand Lestage's description of these parts. I have examined only one ♂ of *barnardi*, the genitalia of which (removed and cleared in potash in the usual manner) are here figured and are in such close agreement with those of the following closely allied genus and species that one mutually confirms the correctness of the other. There are three clearly defined joints, of which the 3rd is much the shortest, the 1st and 2nd being nearly equal to one another. The discrepancy in Lestage's description of the penis, on the other hand, is perhaps merely verbal. I would describe the penis as "single, apically bifid" in preference to "lobes du pénis . . . séparés par un sillon étroit . . ."

Ephemerellina barnardi Lest.

Lestage, 1924A, p. 348.

Imago.—With the above characters. In fore-wing between M_{3+4} and Cu_1 two short marginal intercalaries and one longer one, which, however, is not disconnected but joined to M_{3+4}. Similarly, the longer of the marginal intercalaries between Cu_1 and Cu_2 is joined to Cu_1.

Body ♂ 8–8·5 mm., ♀ 9·5 mm.; wing ♂ 10 mm., ♀ 12 mm.; cerci ♂ 27–30 mm., ♀ 18 mm.

Castaneous, darker in ♂ than in ♀, nearly uniform, but with lighter and brighter marks laterally on mesothorax; abdomen nearly uniform, but with slightly darker bands in ♂, without the conspicuous dark spots on segment 2 found in *L. harrisoni*. Legs fulvous, knees darker, but femora not banded. Cerci rufous, the articulations slightly deeper in colour.

Localities.—Hottentots Holland Mts. (east side, *i.e.* Caledon side) (1 ♂, 1 ♀, January 1916, K. H. B.); Gt. Winterhoek Mts., Tulbagh Div. (♀, November 1916, K. H. B.); Witte River, Wellington Mts. (♂, November 1922, K. H. B.).

Remarks.—The small amount of material available confirms Lestage's description except as regards the ♂ genitalia mentioned above.

This seems to be a mountain form living at higher altitudes than the next species. The original pair was taken in the Hottentots Holland Mts. at about 4000 feet (not 4900 as given by Lestage). The Winterhoek and Wellington specimens were caught at about 3000–4000 feet.

The rarity of the flies seems to indicate nocturnal habits as in the case of *L. harrisoni*.

Ephemerellina nymph.

A nymph collected in the Cedarbergen, Clanwilliam District, in January 1930 (K. H. B.), is clearly allied to the following species, but nevertheless shows such obvious differences as to deserve specific, if not generic, separation. There is every likelihood of its being the nymph of *E. barnardi*. Other similar nymphs were found at Groot Drakenstein by Mr. Harrison in December 1930, and Eerste River in October 1931.

Prothorax longer in proportion to width than in *L. harrisoni*. Prothoracic sternite raised into two rounded knobs separated by a shallow median channel, closely covered with short spinules. Abdominal segments 6–9 shortly acuminate laterally, but not expanded into projecting pleurae as in *harrisoni*; segments 1–8 raised medio-dorsally into projecting, imbricate spinous knobs, especially segments 2–6. Dorsal surface with short blunt spines, especially on posterior margins of segments; lateral margins with short spines; ventral surface of segments 1, 2, and 6–9 (not 3–5) with short spines or minute denticulation. Mouth-parts as in *harrisoni*. Femora less strongly expanded than in *harrisoni*, front margin with densely set, stout clavate spines, like palisades, in more than a single series, giving place distally to more widely spaced spines; hind margin with stout clavate spines and setae; upper surface with very short, scale-like spines; tibiae and tarsi with very fine and dense short fur on inner margins, outer margins with sparse setae. Claws denticulate, the denticles more or less uniform in size, a series of very fine setules distally. Five pairs of gills, the gill on the 1st segment completely obsolete; the gills resembling those of *harrisoni*, but the single lamella on segment 6 relatively smaller. Cerci at least as long as whole body, setose and spinose, but both setae and spines shorter than in *harrisoni*.

Body 8 mm.; cerci 9 mm.

Uniform ochraceous, with faint dark marks dorso-laterally on the posterior abdominal segment; the anterior segments also show faint dark marks nearer the median line; gills greyish, the elytroid gill lamella on segment 2 with a pale oblong transverse spot on either side; cerci with one or two narrow dark annuli at base; eyes black.

The specimen is a ♂, and the 9th sternite is only feebly trifid apically, but might at the next moult approximate to the definitely trifid form found in *harrisoni*.

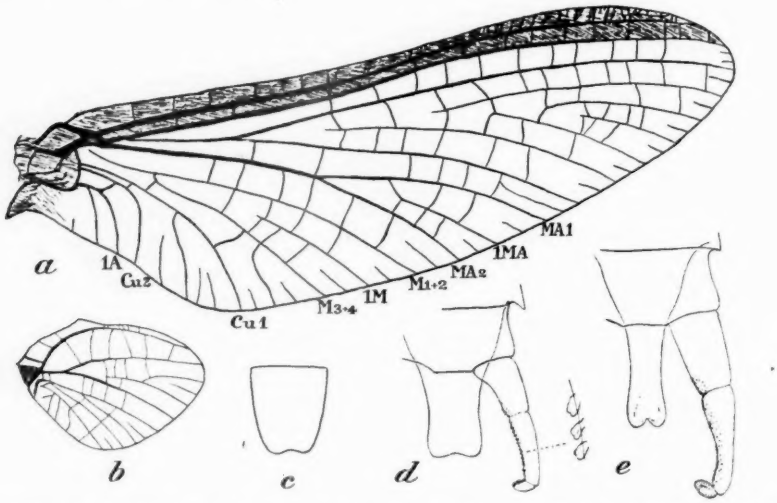


FIG. 42.—*Lithogloea harrisoni* n. g., n. sp. *a*, fore-wing ♀ subimago (ciliation omitted); *b*, hind-wing ♂ subimago; *c*, ventral plate of ♀; *d*, forceps and penis of ♂; *e*, forceps and penis of ♂ of *Ephemerellina barnardi* Lest.

Lithogloea n. g.

Imago.—Like *Ephemerellina* but: fore tarsus of ♂ nearly as long ($\frac{5}{6}$) as tibia, which is $1\frac{1}{4}$ times the length of femur, 1st tarsal joint very short, 2nd longest, 3rd, 4th, 5th decreasing, claws alike. Mid and hind tibiae half length of femora, tarsi half length of tibia, 1st–4th joints subequal, 5th equal to 1st–4th joints together. In ♀ as in *Ephemerellina*. Genital forceps of ♂ as in *Ephemerellina*, but penis broader.

Nymph.—Like that of *Ephemerellina* (assuming the latter is correctly correlated), but with a 2-jointed rudimentary gill on 1st segment, and the prothoracic sternite flat. Closely resembling the nymph of *Torleya*, but with gills on segments 1–6, those on segment 2 more strongly elytroid and covering all the following pairs. Maxillary palp obsolete.

Remarks.—The ♂ imago agrees well with that of *Torleya* (see Lestage, 1924A, p. 347) as regards the forelegs and the penis; but the ♂ forceps, like those of *Ephemerellina*, differ from those of other Ephemerellids.

Lithogloea harrisoni n. sp.

Imago.—♂. Fore tibia 1½ times length of femur, tarsus slightly longer than femur, joints decreasing in length from 1st, claws alike, lamellate, obovate. Tarsal claws of mid and hind tarsi dissimilar. Genital styles, 2nd joint longer than 1st, which is longer than 3rd, inner margin with numerous minute scale-like processes; penis broad, feebly excavate apically.

♀. Tarsal claws of all legs dissimilar. Ventral plate very shallowly excavate distally.

Body ♂ 6 mm., ♀ 6·5 mm.; wing ♂ 6·5 mm., ♀ 7 mm.; cerci ♂ 8 mm., ♀ 9 mm.

♀. Head pale yellowish with bright deep-orange marks on occiput between eyes and between ocelli. Eyes dull greyish orange; ocelli with basal black ring, then an orange ring, apices white. Prothorax with orange or orange-

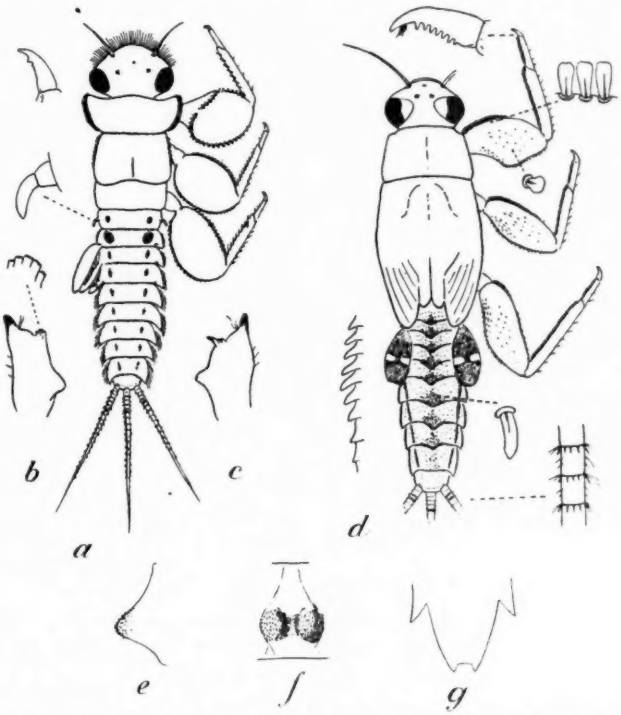


FIG. 43.—*Lithogloea harrisoni* n. g., n. sp. *a*, young nymph, 2 mm. long, with claw and gill on 1st segment further enlarged; *b*, *c*, left and right mandibles. *Ephemerellina* (Cedarberg). *d*, ♂ nymph with profile of abdomen, claw, portion of cercus, and spines further enlarged; *e*, *f*, lateral and ventral views of prothoracic sternite; *g*, 9th sternite of ♂.

brown marks, lateral margin brown. Mesothorax ochraceous or fulvous, laterally with orange and brown patches, scutellum apically more or less orange, laterally dark brown. Metathorax fulvous brown, lighter medio-dorsally and ventrally. Abdomen orange-ochraceous, each segment (except 10) with a short transverse darker bar on posterior margin on either side of median line, which is pale or whitish; and another darker spot or patch antero-laterally; a conspicuous dark-brown spot on pleura of segment 2, and sometimes a less conspicuous one on segment 1; ventrally paler, uniform. Some specimens have a deeper ground-colour than others, with the dark bars and patches more conspicuous, the medio-dorsal line consequently more conspicuously pale. Legs orange-ochraceous, femora with more or less conspicuous dark basal, middle and apical bands, tibiae also suffused in basal third. Cerci pale grey, with narrow orange-brown annulations. Wings clear, fore-wing somewhat milky in pterostigmal area, neuration pale, whitish, C, Sc, and RS greyish distally, a conspicuous dark spot right at base of Sc.

♂ considerably darker, brown, pro-, meso-, and meta-thorax almost Vandyke brown, mesothorax laterally with lighter joinings. Turbinate eyes dark basally, pinkish (in alc.) on top.

Subimago.—Paler, mesothorax medio-dorsally quite pale.

Egg.—Bluntly oval, ·2 mm. long diameter, surface indistinctly pitted, no attachment threads.

Nymph.—Head transversely ovoid, antennae not much longer than transverse width of head. Mouth-parts as figured. A mere chitinous knob indicates the base of the obsolete maxillary palp. Apex of 3rd joint of labial palp minutely scabrous, but not setose. Prothoracic sternite flat. Abdomen triquetral in cross-section, flattened ventrally, convex dorsally; segments 2–8 produced and raised into blunt projecting points medio-dorsally, especially segments 2–5; segments 3–9 laterally acuminate, the points increasing in size posteriorly. Anterior segments

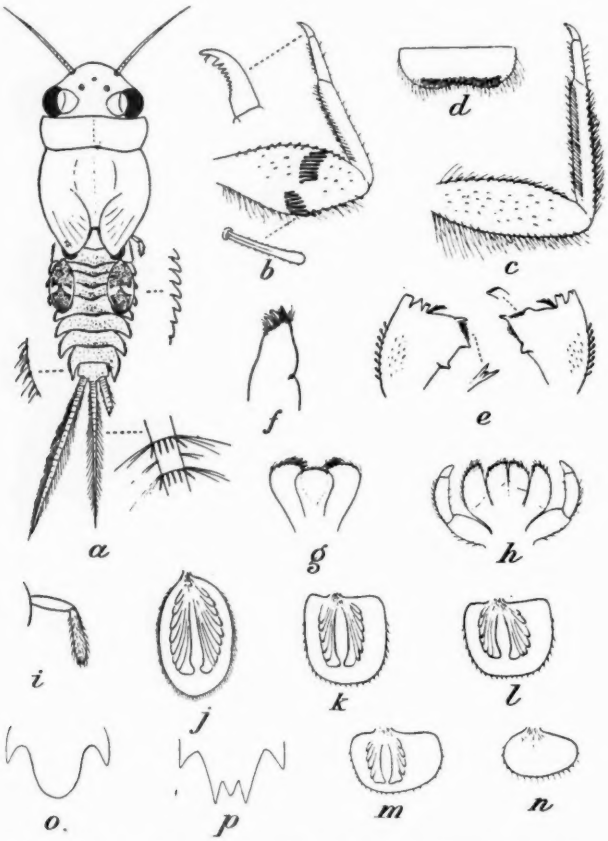


FIG. 44.—*Lithogloea harrisoni* n. g., n. sp. *a*, ♂ nymph, with profile of abdomen, lateral margin of an abdominal segment, and portion of middle cercus further enlarged; *b*, front leg, with claw further enlarged; *c*, hind leg; *d*, labrum; *e*, mandibles; *f*, maxilla; *g*, hypopharynx; *h*, labium; *i*, gill on 1st segment; *j–n*, gills on 2nd–6th segments respectively; *o*, *p*, 9th sternite of ♀ and ♂ respectively.

dorsally, especially on the projecting knobs, with numerous short clavate spines; lateral margins with pointed spines and a few setae; ventrally with minute spines, chiefly on the posterior segments. Femora broadly ovate; front femur broadest, with short clavate spines on front margin, longer clavate or blunt spines forming an interrupted series across middle of upper surface, hind margin with setae and a few spines; tibia with setae on outer margin, spines on inner margin, and a row of stronger spines on upper surface near inner margin; tarsus with spines on inner margin. Middle and hind femora with spines and setae on front margin, and long plumose setae on hind margin; tibiae and tarsi as in front leg, but hind tibia has, in addition, spines and setae on outer margin. All claws denticulate, the distal denticle largest, the others decreasing proximally, 2–3 fine setules distally. Cerci with long spines at articulations of the joints, and long setae, feebly plumose, beginning from about the middle third, decreasing in length distally. Gill on segment 1 rudimentary, curving upwards, 2-jointed, 2nd joint longer than 1st, and setose. Second

gill double, outer lamella ovoid, margin setose, elytroid and concealing almost completely the following gills, inner lamella bilobed, each lobe consisting of a number of delicate imbricate lamellae. Third, fourth, and fifth gills also double, the outer lamella becoming subquadrangular or ovoid, margins setose. Sixth gill a single, delicate, transversely oval lamella, with setose margin.

Younger nymphs appeared at first sight to belong to a different species, but breeding experiments and further collecting refuted this. At about 2 mm. length (cerci excluded) the young nymph or larva has the margins of the head strongly setose, the lateral margin of prothorax, and to a lesser degree also of the mesothorax, with short close-set clavate spines, and the posterior abdominal segments strongly setose laterally. The posterior margins of the abdominal segments are minutely denticulate. None of the segments are dorsally raised or imbricate. The femora are enormously dilated, and the outstanding spines on the front femur form an almost complete hemiwhorl (on upper surface); both front and hind margins of middle and hind femora are strongly spinulose; claws feebly denticulate. Cerci feebly spinose. Mandibles more cylindrical, less triangular. First gill with shorter basal joint. Only three pairs of lamellate gills; those on segments 2 and 3 double as in mature nymph, that on segment 4 single.

At about 4 mm. length the femora are less broadly expanded. The mature features (dorsally imbricate abdominal segments, six pairs of gills, colour, etc.) would appear to be developed suddenly in one moult, but this point has not been definitely proved by breeding.

Up to about 8–9 mm., cerci 3–4 mm.

Very young (2 mm.) and half-grown (4 mm.) nymphs are pale straw colour, yellowish or ochraceous, eyes black, a series of dorso-lateral dark spots on abdomen, one on each segment, that on segment 2 being the largest and most conspicuous.

Larger and fully-grown nymphs are speckled and mottled with various shades of brown, 9th abdominal segment darker than the others, the spot on segment 2 still remaining conspicuous (as in the imago); femora mottled and banded, tibiae more or less dark proximally, pale distally, tarsi dark. Cerci irregularly annulate; in pale-coloured examples there is usually a single dark narrow annulus near base of each cercus. Outer elytroid lamella of 2nd gill suffused, usually with an ovate oblique pale spot on either side.

Localities.—Groot Drakenstein (A. C. H.); Jonkershoek, Stellenbosch (A. C. H.); Banhoek, Stellenbosch (K. H. B.); Table Mt. slopes (K. H. B.); Witte River, Wellington Mts. (2 imagos, November 1922, K. H. B.).

Habits.—Half-grown and fully-grown nymphs are extremely common during spring and summer, October to February or March, in rapidly flowing mountain streams. They live on the undersides of stones, and do not accumulate particles of mud or detritus as camouflage (as do some of the European species of this family) or not to any great extent. They swim clumsily by dorso-ventral flexions of the body.

Emergence of the subimago takes place either after the nymph has crawled up a stone above the water-line, or from the surface film of the water, and occupies only a second or two. Emergence occurs either late in the afternoon or by night. The subimagos are extremely active immediately after emergence. The subimaginal stage may last more than 24 hours in cool weather, but usually less, especially in hot weather.

Their nocturnal habits evidently explain why the flies have only once been taken in a wild state (Witte River).

Suborder HEPTAGENIOIDEA.

Family Ecdyonuridae.

Eaton, 1885, p. 237 *sqq.**; Ulmer, 1920, p. 136.

Imago.—Prothorax well developed. In fore-wing Cu_2 and 1A subparallel, divergent from Cu_1; two pairs of straight intercalaries between Cu_1 and Cu_2, the longer pair always proximal to the shorter pair, *i.e.* nearer to Cu_2. Hind-wing ovoid.

Nymph.—Of the crawling type, strongly flattened. Head usually large. Eyes dorsal. Labial and maxillary palps 2-jointed. Legs strong, claws usually dentate. Cerci 2 or 3, elongate. Gills 7.

The nymphs of this family are characteristic of swiftly running streams, to which their structure is well adapted.

Only one genus is known for certain from Africa. Eaton (1913, p. 277) records some fragmentary specimens from British East Africa which appear to have affinities with *Epeorus*.

Gen. *Afronurus* Lest.

Lestage, 1924a, p. 349.

Imago.—Cross-veins in fore-wing numerous, forming a close network. Hind-wing broadly ovoid, neuration well developed, MA forked. Hind tarsus much shorter than femur, 1st joint slightly longer than 2nd. Fore tarsus of ♂ with 1st joint shorter than 2nd and 3rd, but longer than 5th joint. All claws in both sexes dissimilar. Penis broad, apically incised.

Nymph.—In general like that of *Ecdyonurus* (see Lestage, 1921, p. 203, fig. 52).

Afronurus peringueyi (E.-P.).

Esben-Petersen, 1913, p. 185, figs. 9–12; Navas, 1915, p. 173; Lestage, 1918, p. 109; Lestage, 1924a, p. 351.

The following notes on material in the South African Museum are supplementary to Esben-Petersen's description.

Imago.—The outer apex of the femora is produced in a rounded lobe or flange, especially in the mid and hind legs, which has the appearance of a spine in dorsal view. In Esben-Petersen's figure 10 the small size of the hind

* Eaton's original spelling of the name of the genus, from which this family takes its name, must stand.

leg of ♀ is evidently due to a draftsman's error. A better figure of the penis is here given, taken from a preparation in liquid. The ventral plate of ♀ is sharply and rather deeply excised on distal margin.

Major and Minor Forms.—The small amount of material sent to Esben-Petersen was insufficient to give a hint that two forms are present. In fact the whole of the S.A. Museum material would not do that except by analogy with the Cape species described below. The details of the material are as follows:—

Forma Major.—♀ October 1911 (Type, not in S.A. Mus.), February 1912, March 1917; subimago ♀, October 1911 (not in S.A. Mus.), December 1914, February 1912, March 1917.

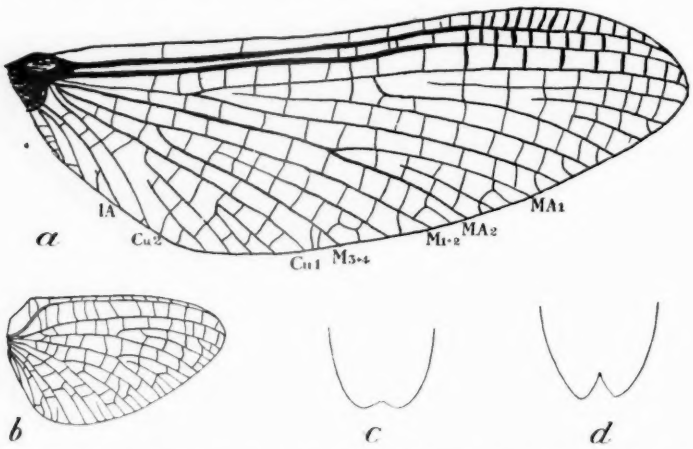


FIG. 45.—*Afronurus harrisoni* n. sp. *a*, *b*, fore- and hind-wings of imago; *c*, *d*, ventral plate of ♀ of *harrisoni* and *peringueyi* respectively.

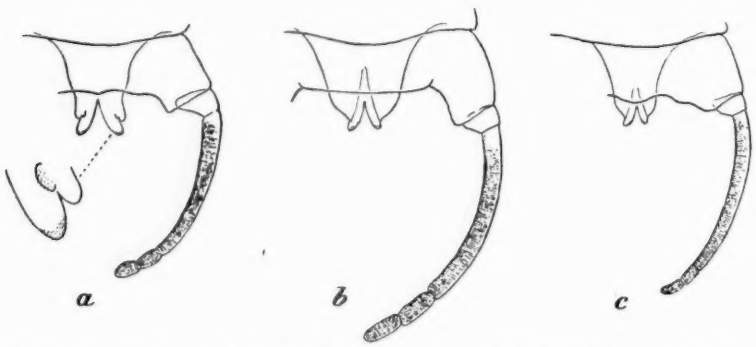


FIG. 46.—*Afronurus*. Forceps and penis of ♂ of: *a*, *peringueyi* (E.-P.); *b*, *c*, *harrisoni* n. sp. *forma major* and *forma minor* respectively.

Forma Minor.—♂, September 1911, December 1914, April 1916 and 1917; subimago ♂, December 1914, April 1917; subimago ♀, December 1914, April 1916.

All the ♂♂ are *forma minor*, and most of the ♀♀ are *forma major*.

Localities.—Besides the one locality in Zululand, this species has been recorded from the Belgian Congo (Navas, 1915, and Lestage, 1918) though with some doubt.

The capture of a ♀ specimen (*forma minor*: body 7·5 mm., wing 9 mm.) on the Kunene River, near Erikson's Drift, Ovamboland (March 1923, K. H. B.) bridges to some extent the gap in the distribution. The species will probably be found in the Transvaal, and the presence in Natal of nymphs, which are almost certainly this species, indicates that it occurs in Natal also.

Nymph assigned to *Afronurus peringueyi*.

Head regularly oval. Antennae short. Abdominal segments finely spinulose dorsally on posterior margins; segments 3–8 with the postero-lateral angle acuminate, the points becoming stronger posteriorly. Femora broadly lamellate, anterior margin with spines especially in mid and hind legs, dorsal surface with spines which are blunt on front femur, pointed on mid and hind femora; hind margins with long plumose setae, and with short spines also on mid and hind femora. Fore tibia sparsely setose, mid and hind tibiae densely setose and with a few spines; claws stout, inner margin with 5 denticles. Gills: lamella of 1st gill elongate oval, of 2nd–6th gills subtriangular, of 7th gill long-oval, the branchial filaments of the latter much shorter than in the other gills; margin of 7th lamella setulose, all the others smooth.

Size of specimens, which do not appear to be fully grown: 10 mm.

Colour as preserved: dark brown, eyes black, ocelli apically pale; thorax, abdomen, and femora mottled, abdomen, with two pale subdorsal spots on each segment except the 10th; tibiae and tarsi pale, the former with a fuscous band in middle; cerci annulate.

Natal (no exact locality); collected by Mr. L. A. Day, Provincial Inland Fisheries Officer of Natal.

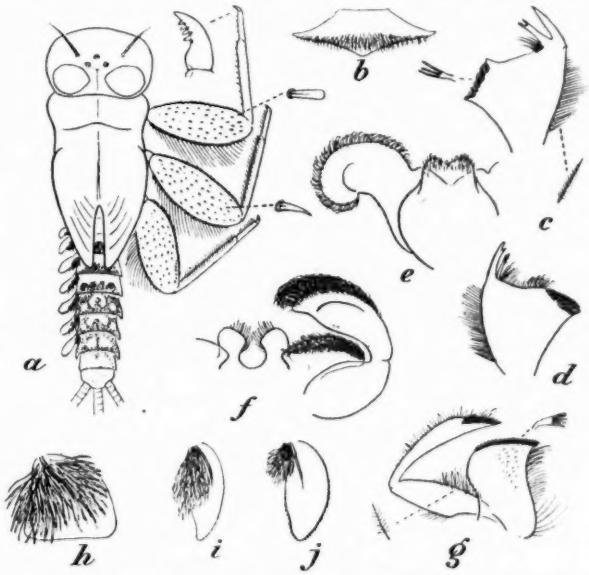


FIG. 47.—*Afronurus peringueyi* (E.-P.). *a*, nymph with claw and femoral spines further enlarged; *b*, labrum; *c*, *d*, left and right mandibles; *e*, hypopharynx; *f*, labium; *g*, maxilla; *h*, *i*, *j*, inner view of 2nd, 1st, and 7th gills respectively.

Afronurus harrisoni n. sp.

Eaton, 1887, p. 309 (*Ecdyurus* sp. ♀ from Paarl).

Imago.—Venation as in *peringueyi*. ♂ styles as in *peringueyi*. Penis apically bifid, the lateral margins sinuous, the apical lobes grooved on the underside and the tips curved downwards. Ventral plate of ♀ shallowly excised on distal margin.

Two forms occur, which are distinguished as *forma major* and *forma minor*. *Forma major*: body ♂ 11·5 mm., ♀ 12 mm.; wing ♂ 12 mm., ♀ 13 mm.; cerci ♂ 24 mm., ♀ 25 mm. *Forma minor*: body ♂ 8–9 mm., ♀ 9·5 mm.; wing ♂ 8·75–9 mm., ♀ 10·5 mm.; cerci ♂ 13–19 mm., ♀ 18 mm.

Turbinate eyes of ♂ at first caesious, turning reddish orange or flavous, with two burnt sienna bands laterally; ocelli shining piceous. General colour varying from light yellow to orange, darkening with age, with a dorsal stripe of burnt sienna or reddish orange. Abdomen laterally with a dark comma-shaped mark on each segment, and ventrally a median sienna stripe. Legs brownish. Genital styles light sienna. Cerci light reddish brown with sepia annulations. ♀ similar to ♂ but often with a deeper red or purplish shade on abdomen.

Egg.—One ♀ lived in captivity for six days and then extruded an egg-mass (unfertilised). The portion of the egg-mass external to the body is connected with the remainder still inside the body. It is a hard mass, as preserved, and the eggs are connected with one another by fine, tough, elastic threads. These threads do not appear to arise from any particular part of the egg. The eggs are pale yellow, ovoid, shallowly sculptured.

Nymph.—As in *peringueyi*, with the following differences: head larger, broader, the lateral margins not parallel but converging posteriorly; femora relatively not quite so broadly lamellate, spines on upper surface of fore femur pointed like those on the other femora. 7th gill more broadly ovate, without any filaments.

Colour: see *infra*.

Localities.—Groot Drakenstein (A. C. H.); Jonkershoek, Stellenbosch (A. C. H.); Hex River, Sandhills, Worcester Distr. (A. C. H.); River Zonder End Mts. (November, December, 1928, K. H. B.); French Hoek (K. H. B.).

Remarks.—This species is clearly distinct from the Zululand species in the ♂ genitalia (penis), ventral plate of ♀, and even more strikingly in the nymph. I have much pleasure in naming this fine Cape May-fly after Mr. Harrison, who has worked out the life-history.

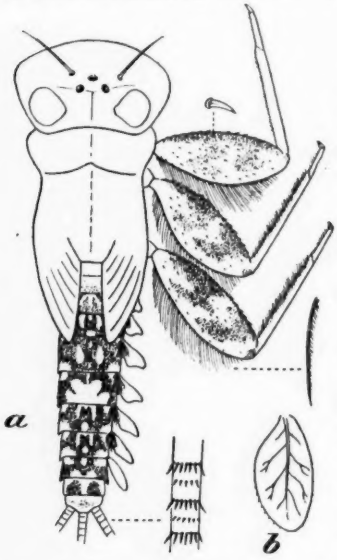


FIG. 48.—*Afronurus harrisoni* n. sp. *a*, nymph, with portion of cercus and spines further enlarged; *b*, 7th gill.

Habits.—The flies occur from late October to mid-March, being most abundant about Christmas and New Year.

The nymphs live in running water; young instars can be found throughout the year, but full-grown nymphs are conspicuous only in late spring and early summer. The nymphs live on the undersides of stones, either deeply submerged or at the margin of the stream; they are very agile and dodge round from one surface to another when the stone is lifted out of the water. They are difficult to dislodge from the stone. Their swimming is laboured, the legs aiding the flexions of the body (A. C. H.).

The coloration is variable, but there are two main types of coloration: the commoner variety is the "tawny-yellow" with predominating yellowish ground-colour and broad reddish-brown markings on head, thorax, abdomen, and legs, ventral surface and cerci pale yellowish; the other variety is the "partridge-mottled," in which the whole upper surface and the cerci are brown-mottled.

Emergence of the subimago takes place by night, either from the surface film or subaqueously. In the latter case the nymph skin remains firmly attached to a stone or piece of weed not less than 1 inch from the surface (in aquarium). The subimago from a subaqueous emergence slips out of the nymph-skin, shoots up to the surface with wings folded plicately along the abdomen, and, bursting through the surface film, rests on the surface for an instant on its legs before taking flight to a neighbouring object (A. C. H.).

Nymphs ready to disclose the subimago are sensitive to light. If the electric light be switched on during the usual restlessness just prior to emergence, the insect is distressed and ecdysis interrupted, often resulting in death. If, however, ecdysis has actually begun, and the nymph-skin split along the back, light has little or no effect (A. C. H.).

Transformation to the imago follows about 24–36 hours later, the shortest times being during hot weather. Imagos have been kept alive for six days (A. C. H.).

In the subimago variations in the shade of the prevailing body colours, yellowish brown and reddish brown, are found. The following are the three varieties of wing coloration, in order of frequency:—

1. Membrane dull hyaline yellow, neuration shaded with brownish.
2. Membrane shaded with brownish, except the marginal area, which is yellowish, neuration bright hyaline yellow.
3. As in 2, but neuration shaded with deeper brownish.

All three varieties of subimago can emerge from either the "tawny-yellow" or the "partridge-mottled" type of nymph (A. C. H.).

The above remarks apply to both *forma major* and *forma minor*, except that all the bred subimagos of the "Dwarf Tawny-Yellow" belong to variety 2; there were none of variety 1, which is the commonest in *forma major*.

BIBLIOGRAPHY.

EATON, A. E., 1883–1888, "A Revisional Monograph of Recent Ephemeridae or May-flies," Trans. Linn. Soc. Lond., 2nd ser. zool., vol. iii. (The dates of issue of the six parts are stated on the page following the title-page of the volume.)

EATON, A. E., 1913, "Ephemeridae from Tropical Africa," Ann. Mag. Nat. Hist. (8). vol. xii, pp. 271–278, 3 text-figs.

ESBEN-PETERSEN, P., 1913, "Ephemeridae from South Africa," Ann. S. Afr. Mus., vol. x, pp. 177–187, figs. 1–12.

ESBEN-PETERSEN, P., 1920, "New Species of Neuropterous Insects from South Africa (Ephemerida, Megaloptera, and Embiidina)," Ann. S. Afr. Mus., vol. xvii, pp. 499–502, fig. 4.

LESTAGE, J. A., 1916, "Contribution à la connaisance des Larves des Ephémères du Congo Belge," Rev. Zool. Afr., vol. iv, pp. 314–319, figs. 1, 2.

LESTAGE, J. A., 1917, "Deuxieme contribution à l'étude des Larves des Ephémères du Congo Belge," Rev. Zool. Afr., vol. v, pp. 121–134, figs. 1–6.

LESTAGE, J. A., 1918, "Les Ephémères d'Afrique (Notes critiques sur les espèces connues)," Rev. Zool. Afr., vol. vi, pp. 65–114, figs. 1–4.

LESTAGE, J. A., 1921, "Ephemeroptera." In Rousseau, Les Larves et Nymphes aquatiques des Insects d'Europe, vol. i, pp. 162–273, figs. 40–72, Brussels.
LESTAGE, J. A., 1923, "Les *Cloeon* africains et description d'une espèce nouvelle du Congo Belge," Rev. Zool. Afr., vol. xi, pp. 192–195, fig. (July).
LESTAGE, J. A., 1923A, "Étude des Ephémères du Congo Belge. I. Notes sur *Eatonica schoutedeni* Nav.," Rev. Zool. Afr., vol. xi, pp. 301–307 (October).
LESTAGE, J. A., 1924, "Notes sur les Ephémères de la Monographical Revision de Eaton," Ann. Soc. Ent. Belg., vol. lxiv, pp. 33–60 (July).
LESTAGE, J. A., 1924A, "Les Ephémères de l'Afrique du Sud. Catalogue critique et systématique des espèces connues et description de trois genres nouveaux et de sept espèces nouvelles," Rev. Zool. Afr., vol. xii, pp. 316–352, 1 fig. (August).
LESTAGE, J. A., 1924B, "Études sur les Ephémères du Congo Belge. II. Un nouveau *Cloeon* du Katanga (*Cloeon smaeleni* nov. sp.)," Rev. Zool. Afr., vol. xii, pp. 426–428, 1 fig. (November).
NAVAS, L., 1915, "Notes sur quelques Neuropteres du Congo Belge," Rev. Zool. Afr., vol. iv, pp. 172, 173, fig. 1.
NAVAS, L., 1929, "Insectes du Congo Belge," Rev. Zool. Bot. Afric., vol. xviii, pp. 109–111, figs. 20, 21.
NEEDHAM, J. G., 1920, "African Stone-flies and May-flies collected by the American Museum Congo Expedition," Bull. Amer. Mus., vol. xliii, pp. 35–40, pl. v.
NEEDHAM, J. G., and H. E. MURPHY, 1924, "Neotropical Mayflies," Bull. Lloyd Libr., Cinc., Ohio, No. 24, Entomol, Ser. 4, pp. 1–65, pls. i–xiii.
PHILLIPS, J. S., 1929, "A Report on Trout Food," New Zeal. Fish. Bull., 2, pp. 1–31, pls.
PHILLIPS, J. S., 1930, "A Revision of New Zealand Ephemeroptera," Trans. N.Z. Inst., vol. lxi, pp. 271–390, text-figs. and pls., 50–67.
ULMER, G., 1916, "Ephemeropteren von Aquatorial-Afrika," Arch. Naturg., vol. lxxi, 1915, Abt. A, pp. 1–19, figs. 1–23.
ULMER, G., 1920, "Ubersicht über die Gattungen der Ephemeropteren nebst Bemerkungen über einzelne Arten," Stettin. Entom. Zeit., vol. lxxxi, pp. 97–144.
ULMER, G., 1920A, "Neue Ephemeropteren," Arch. Naturg., vol. lxxxi, 1919, Abt. A, pp. 1–80, figs. 1–56.
ULMER, G., 1921, "Über einige Ephemeropteren-Typen älterer Autoren," Arch. Naturg., vol. lxxxvii, 1921, Abt. A, pp. 229–267, 21 text-figs.

ADDENDUM.

Gen. *Acentrella* Bgntsn.

See Lestage, 1921, p. 257.

Acentrella capensis n. sp.

Imago.—Venation resembling that of *Baetis harrisoni* (cf. fig. 12A), including the incomplete longitudinal branchlets in the pterostigmal area, and 1A distally forked, but the short branch disconnected. Hind-wing as in *B. harrisoni*, but costal process more sharply acute.

Body 5–6 mm.; wing 6·5–7·5 mm.

Colour as in *B. harrisoni*, but without colour-pattern on abdomen, except the darker hind border to each segment, cerci annulate.

Egg.—Broadly oval, ·12 mm.

Nymph.—Resembling that of *B. harrisoni* (cf. fig. 13), but with inconspicuous light-coloured tracheae in gills. The median cercus is represented by a minute conical point.

7 mm. Ochraceous, abdomen with a series of medio-dorsal dark marks on each segment, forming a discontinuous dark longitudinal stripe on either side of the median line; knees dark; cerci browinsh, uniform.

Localities.—Hex River, Worcester Distr. (October 1931, A. C. H.); Lilyfontein, Kamiesberg (September 1931, K. H. B.); Wellington Mts. (October 1931, K. H. B.); Eerste River, Stellenbosch (October 1931, A. C. H.); Groot Drakenstein (October–November, A. C. H.).

Habits.—The method of oviposition was observed in the Hex River (A. C. H.). The ♀♀ settle on large stones protruding from the water; they crawl down the sides beneath the surface, with wings folded along the abdomen, and lay masses of eggs on the under surface of the stones. After oviposition the ♀♀ crawl out of the water, the wings soon dry, and they are again capable of flight.

Some eggs collected on 5th October (actual date of oviposition not known) hatched on 19th–20th October (*i.e.* not less than 14 days). The newly hatched larvule, like most other 1st stage larvules, has only 2 cerci.

Unlike other Baetids, the nymphs are stone-clingers and runners rather than swimmers. When a stone is disturbed the ordinary Baetid nymphs dart away with great rapidity, but the *Acentrella* nymphs remain clinging. Thus in habits they closely resemble a Leptophlebiid, e.g. *Castanophlebia*.

A fuller description, with figures, of this interesting May-fly, which was discovered too late for inclusion in the body of this paper, will be given elsewhere.

CONTRIBUTIONS TO A KNOWLEDGE OF THE TRANSVAAL IRIDACEAE. PART II.

By N. E. BROWN, A.L.S.

(Communicated by J. BURTT DAVY, M.A., Ph.D.)

In a previous article (Trans. Roy. Soc. S. Afr., xvii, 341) some account was given of the genera belonging to the Morea group of the Iridaceae. I now present a further account of some alterations it has been found necessary to make, together with descriptions of several new genera belonging to the Tribe Ixieae.

It is well known that the whole order Iridaceae urgently requires revision, but it is not until one commences to work upon it that it is realised how great the necessity for a complete revision by a really competent worker has become ; erroneous naming of the species has been widespread, and there is no means of otherwise rectifying it. Existing definitions of the genera, and the keys to them, are very imperfect and most unsatisfactory. So that the Iridaceae offer an ample field for a really good and experienced worker to test his metal ; it is really a difficult family, and not one for an amateur to attempt.

In the course of my work I have only investigated the few genera that inhabit the Transvaal, but the outcome of this investigation indicates that many genera of other regions are probably in as confused a state as I have found some of the Transvaal genera to be. The genus *Dierama* affords a good example of specific confusion ; previous monographs only admitted two species and a variety, yet on examination of the very same material enumerated under those two species I found it to consist of no less than fourteen perfectly distinct species, one of which, however, had been wrongly placed under another genus ! And as an example of generic confusion it is doubtful if a more chaotic example can be found than that afforded by the genus *Antholyza*, as generally understood, which I was very surprised to find consisted of a mixture of several dissimilar types of structure, not one of which conformed with the generic characters of *Antholyza* as set forth by Linné in the various editions of his Genera Plantarum (from 1st ed., p. 10, to 5th ed., p. 25 (1754)) ; also that the plant upon which Linné actually founded the genus *Antholyza* had been excluded from that genus by Ker and placed under *Babiana*, founded by

Ker over fifty years later than *Antholyza*, and to which it certainly does not belong! As I have given under *Antholyza* a full account of the confusion made by various authors under this genus, it is not necessary to repeat it here. But it is hoped that the establishment of the new genera here made will help to clear up some of the confusion into which the Iridaceae have unhappily fallen.

Tanaosolen N. E. Brown, gen. nov.

Leaves cauline, very reduced, linear. Spike lax. Bracts 5–8 mm. long, unequal and the inner longer than the outer one, firm. Flower subregular; tube 5 or 6 times as long as the bracts, slender and scarcely enlarged at the mouth; lobes all similar, the upper one a little longer than the other five. Stamens exserted, apparently all dorsal; anthers sagittate. Style exserted, slender; style-arms cuneate and entire. Ovary oblong, obscurely angled, with about 4–5 ovules in each cell.

The name is derived from the Greek *tanaos*, long, and *solen*, a tube, in allusion to the long tube of the flower.

A monotypic genus, native of South Africa.

T. nudus N. E. Brown, sp. nov. A tall plant, 80–120 cm. high. Bulb not seen. Leaves on the stem about 3, reduced, 3–4 cm. long, 1–1·5 mm. broad, subulate-linear, acute, besides one or two sheaths. Stem 2–4 mm. thick, terete, naked, with the internode below the spike 40 cm. or more long. Spike 11–15 cm. long, with 12–16 flowers 5–22 mm. apart. Bracts 7–8 mm. long, acute or subobtuse and apiculate, firm, the outer shorter than the inner one, brown on the dried specimen. Flowers erect; tube 3–4 cm. long, very slender, not more than 1 mm. in diameter when dried; dorsal lobe about 12 mm. long, the other 5 about 9–10 mm. long, all cuneately or spathulately oblanceolate, obtuse, apparently laxly spreading, possibly yellowish or creamy white. Anthers 4 mm. long. Style-arms 1–2 mm. long, cuneate, entire.

Cape Province.—Ceres Division: Cold Bokkeveld at Sandfontein, *Schlechter* 10136.

Radinosiphon N. E. Brown, gen. nov.

Corm subglobose or conical-globose. Leaves laterally flattened and linear or filiform. Stem simple or branched. Spike lax, with 2–10 flowers. Bracts herbaceous 7–18 mm. long. Flowers small; tube slender, 2–4 times as long as the bracts, slightly enlarged and curved immediately under the lobes, which are all narrow, with the upper one rather broader than the others and slightly arched. Stamens under and shorter than the upper lobe of the flower; anthers sagittate. Style exserted and longer or shorter

than the stamens; style-arms short, entire. Capsule subglobose, shorter than the bracts. Seeds flattened and angular.

The name is derived from the Greek *radinos*, slender, and *siphon*, a tube, in allusion to the very slender tube of the flower.

The plants forming this genus were originally placed under *Lapeyrousia*, but their entire stigmas clearly distinguish them from that genus, and as there was no other genus than either *Gladiolus* or *Acidanthera*, to which they could be referred, they were placed under *Acidanthera* on account of the long and slender tube of the flower. But in the small size, narrow segments and obliquity of the flowers, and in the general appearance of the plants they distinctly differ from that genus; while from *Gladiolus* their general appearance and the long and very slender flower-tube at once distinguish them. I have, therefore, founded the present genus for their reception.

Species 5, natives of South and Tropical Africa.

The following is a descriptive key to all the species, all measurements being taken from dried specimens :—

a. Leaves few, filiform and less than 1 mm. broad; plant 25–35 cm. high; bracts 1·5–2 cm. long; flowers 3–6 to a spike; tube 3·5 cm. long, lobes 2–2·5 cm. long, "deep cream or buff with purple markings on the lower lobes." South Africa, locality unknown. (*Gladiolus leptosiphon* Bolus, Ann. Bol. Herb., 1 : 195). *R. leptosiphon* N. E. Br., comb. nov.

a. Leaves laterally flattened, linear and 2·5–9 mm. broad, *b.*

b. Plant 10–13 cm. high; leaves 5–9 cm. long, 2·5–4 mm. broad; inflorescence a simple lax spike with 2–3 flowers; bracts 8–10 mm. long; tube of flower 15–20 mm. long; lobes 7–8 mm. long and 1·5–3 mm. broad, apparently dark lilac or violaceous; stamens exceeding the violaceous stigmas. Nyasaland: Mount Chiradzulu, *Cameron* 179 (type)! . . . *R. Cameronii* N. E. Br., sp. nov.

b. Plant 30–70 cm. high (seedlings sometimes smaller); leaves 9–40 cm. long, 3–9 mm. broad, *c.*

c. Stamens exceeding the stigmas; inflorescence often branched, with 3–10 flowers to a spike; flower-tube 14–30 mm. long; lobes 8–11 mm. long, the broadest one about 2 mm. broad, all mauve or pink. Transvaal (*Lapeyrousia leptostachya* Baker Handb. Irid. 170; Fl. Cap. 6 : 95; *Acidanthera leptostachya* N. E. Br.) . . . . . *R. leptostachya* N. E. Br., comb. nov.

c. Stamens shorter than the stigmas, *d.*

d. Inflorescence branched or simple, with 4–9 flowers to a spike; tube of flower 25–40 mm. long; lobes 12–15 mm. long, the broadest one about 3·5 mm. broad; flowers stated to be "striped puce." Transvaal, Lomati Valley, *Thorncroft* 1065 (type)! (*Acidanthera lomatensis* N. E. Br. Kew. Bull. 1921 : 298 . . . . . *R. lomatensis* N. E. Br., comb. nov.

d. Inflorescence unbranched, with 3–5-flowers; tube of flower 20–30 mm. long; lobes 10–11 mm. long, the broadest one 3 mm. broad, all apparently pale pink or lilac. East Tropical Africa: Fwambo, S. of Lake Tanganyika, *Carson* 14. (*Lapeyrousia holostachya* Baker in Kew Bull. 1894: 391; *Acidanthera holostachya* N. E. Br.) . . . *R. holostachya* N. E. Br., comb. nov.

CROCOSMIA Planch.

This genus has hitherto been so unsatisfactorily defined that plants belonging to it have been placed under *Tritonia*, from which it differs in appearance, bracts and fruit, as indicated in the following contrasted characters of these genera :—

Outer bracts (except sometimes of the lowest flowers) notched, toothed or obtuse at the apex when flattened out, 5–15 mm. long, usually thin ; inflorescence simple or branched ; capsule oblong, distinctly longer than broad, not conspicuously 3-grooved ; seeds more than three in a cell ; flowers white, rosy, dark red or orange.

Tritonia.

Outer bracts acute or obtuse and apiculate at the apex, 4–9 mm. long, not very thin, and spreading at a wider angle from the stem than in *Tritonia* ; inflorescence branched ; capsule subglobose, as broad as or broader than long, 3-grooved or 3-lobed ; seeds (by abortion) 1–2 in a cell ; flowers orange to brick scarlet.

Crocosmia.

The plants belonging to *Crocosmia* are 40–125 cm. high, with globose corms that increase by stolons, ensiform leaves 1–2 cm. broad, and usually a branched inflorescence of orange-scarlet or scarlet-red flowers.

Besides the Transvaal species (*C. aurea* Pl.) the following should also be transferred here from Tritonia :—

Crocosmia Masonorum N. E. Br., comb. nov. (*Tritonia Masonorum* L. Bol. in Ann. Bol. Herb., 4 : p. 43).

Crocosmia Pottsii N. E. Br., comb. nov. (*Tritonia Pottsii* Baker, not Bentham as wrongly quoted in Fl. Cap. 6 : 127 ; *Montbretia Pottsii* Baker.)

Crocosmia crocosmiflora N. E. Br., comb. nov. (*Tritonia crocosmiflora* Nicholson Dict. Gard. 4 : 94). This is a garden hybrid between *C. aurea* Planch. and *C. Pottsii* N. E. Br.

Crocosmia maculata N. E. Br., sp. nov. (*Crocosmia aurea* var. *maculata* Baker, Fl. Cap. 6 : 129).

There is another species in the Kew Herbarium, of which the following is a brief description :—

C. latifolia N. E. Br., sp. nov. Plant probably 80–100 cm. high. Leaves 30–42 cm. long, 2–4 cm. broad, lanceolate-ensiform, broadest at the middle, acute, much more coarsely veined than those of *C. aurea* or *C. maculata*. Branches of the inflorescence stout, apparently dull violaceous green, with 11–16 flowers to a spike, crowded in bud, becoming lax as they expand. Bracts subequal, 10–13 mm. long, obtuse, apiculate. Tube of the flower

1·5–2·5 cm. long; lobes 17–20 mm. long, 6–7 mm. broad, bright orange-scarlet. Stamens and style about as long as the lobes. Style-arms 4 mm. long, with broadly cuneate entire stigmas.

Described from cultivated specimens. Collector and locality unknown.

Antholyza Linn.

Corm subglobose. Leaves radical, plicate, linear or linear-lanceolate, acute. Stem erect or somewhat curved, pubescent, usually producing one sessile lateral flower-spike bent at a wide angle from it near the base, the upper part of the stem being naked, with a few barren bracts or a single flower at its apex. Spike densely several-flowered, with the flowers all on the upper side. Bracts 2·5–4 cm. long, herbaceous, acute and awned or mucronate, pubescent, obliquely ascending from the axis. Flower two-lipped and the lips widely gaping; tube curved, funnel-shaped and very much compressed above the middle; upper lip formed of one spathulate lobe with the wavy margins of the lower part inrolled so as to form a tube enclosing the stamens and style, and the upper part lanceolate flattened and recurved; lower lip of five unequal lobes arising from the projecting front of the mouth of the tube. Stamens inserted at about the middle of the tube and usually longer than the upper lip of the flower. Style exserted beyond the stamens, with filiform style-arms papillose all along the inner side. Ovary with 5–6 ovules in each cell. Fruit not seen.—Linn. Gen. Pl., 5th ed., p. 25 (1754); Mill. Dict., 8th ed.; not of other authors.

The only species belonging to this very distinct genus is *A. ringens* Linn., which is wrongly placed under the genus *Babiana* in Fl. Cap., vi, 114. A native of South Africa.

The genus *Antholyza* was founded by Linné (see Linn. Gen. Pl., 4th ed., p. 22) upon a plant figured by Commelin in Hort. Med. Amstelodamensis Rar. Pl., p. 81, t. 41, which Linné named *Antholyza ringens*, and in his description of the genus he states that one of the stamens is incumbent on the lower lip of the flower. It is represented so in the figure from which he described, but is quite anomalous and of very rare occurrence. In his Species Plantarum, p. 37, however, he associates with it a second species that he names *A. cunonia*, but adds a note to the effect that *A. cunonia* may perhaps be found to belong to another genus when the flowers of both plants are further examined. These two plants are all that Linné placed under the genus *Antholyza* in 1753. Ker, however, in Konig and Sims, Annals of Botany, i, p. 233 (1804), refers *A. ringens* to his genus *Babiana*, which he had established in 1802 upon the plant figured as *Babiana plicata* in Bot. Mag., t. 576. And he refers (Ann. Bot., i: 230) *A. cunonia* Linn.

to the genus *Gladiolus*, thus abolishing altogether the genus *Antholyza* as originally established by Linné. Ker, however, applies the generic name *Antholyza* to the plant figured in Bot. Mag., t. 561 (1802), as *Antholyza aethiopica*, and in Konig and Sims, Ann. Bot., i, 233, associates with it *A. lucidor* Thunb., *A. caffra* Ker, and *A. montana* Ker. In this confusion Ker has been followed (evidently without investigation) by all subsequent authors, including myself. For when comparing the Iridaceae of Thunberg's and Burmann's herbaria, I had supposed that the validity of the genus had been investigated by those who had written upon this family, and therefore I took the genera as I found them, without investigation. But having now made an examination of the plants placed under the genus *Antholyza* by modern authors, I find that not a single one of them belong to that genus as established by Linné! I therefore restore to *Antholyza* the plant upon which Linné founded the genus, which is quite distinct from *Babiana* (founded nearly fifty years later), and have grouped the remaining species under eight other genera, all of which have good distinctive and easily recognised characters.

In reference to the very remarkable naked stem produced above the spike of flowers, Dr. R. Marloth, in his Flora of S. Africa, iv, p. 149, t. 44, calls attention to the fact that the sun-birds use this barren stem as a perch when obtaining honey from the flowers, and his figure represents one of these birds resting upon it. Mr. C. A. Smith informs me that he also has often seen these birds visiting the flowers in the manner stated. As I think this is the only iridaceous plant that has developed a barren stem of this nature, it suggests a problem in evolution as to the manner and reason for this adaptation for the cross-fertilisation of the flowers of this peculiar plant. For the pollen of the long-exserted stamens becomes dusted upon the head or breast of the bird when it visits the flowers and is carried to the flowers of another plant, and so fertilises it. How was this mutual benefit to plant and bird developed?

Since writing the above I find in the International Botanical Congress, Cambridge, 1930, p. 18, in an article entitled "Standard species of Linnean genera of Phanerogamae," by A. S. Hitchcock and M. L. Green, that it is proposed to retain *A. cunonia* L. as the type of the genus *Antholyza*, the full text being as follows:—

"65. *Antholyza*, L. Sp. Pl., 37; Gen. Pl., 5th ed., 24.

"*A. cunonia* L., the one of the two original species now retained in the genus. The other is *A. ringens*."

There is not a word of explanation why *A. cunonia* should be chosen, nor what is to be done with the real type of the genus (*A. ringens*), nor any suggestion as to what should be done with the other heterogeneous assemblage of species hitherto placed under the genus.

This is a good example showing the folly of accepting any of the names proposed in that list without fully investigating their claim to be accepted. For it is incredible that knowing all the facts as I have above detailed them, any South African botanist or any botanical congress would ever accept such a proposal as that made to constitute *A. cunonia* the type of the genus to the rejection of the real type, for which, of course, a new genus would then have to be established, as it most certainly is not a *Babiana*, and no two allied genera could be more distinct than are represented by *A. ringens* and *A. cunonia*.

Of the species retained under *Antholyza* in the Index Kewensis most have been referred to the new genera here described, but there are a few others that certainly belong to other genera, which I enumerate below.

A. baguirmiensis Cheval., Étud. Fl. Afr. Centr. Franc., 1 : 304. Name only, not seen ; probably a *Gladiolus*.

A. cabrae De Wild., Ann. Mus. Congo, Ser. v : 15 = *Gladiolus cabrae* N. E. Br., comb. nov.

A. djalonensis Chev., Expl. Bot. Afr. Occ. Franc., 1 : 634. Name only, not seen ; probably = *Gladiolus* sp.

A. Fleuryi Chev., Expl. Bot. Afr. Occ. Franc., 1 : 634. Name only ; probably = *Gladiolus* sp.

A. labiata Pax = *Gladiolus labiatus* N. E. Br., comb. nov.

A. laxiflora Baker = *Gladiolus antholyzoides* Baker.

A. paludosa Chev., Étud. Fl. Afr. Centr. Franc., 1 : 304. Name only, not seen ; probably = *Gladiolus* sp.

A. pubescens Vaupel in Notizbl. Bot. Gart. Berlin, 7 : 375. Not seen ; genus doubtful.

A. quinquenervia Schrank., Comm. Irid. Cap., 56. Not seen ; is probably a species of *Babiana*.

A. Schlechteri Baker in Bull. Herb. Boiss., ser. 2, 4 : 1007. Not seen ; probably = *Gladiolus* sp.

A. sladeniana Pole Evans, in Ann. Bol. Herb., 3 : 13. This is an error for *Aloe sladeniana* Pole Evans.

A. speciosa Wright, in Kew Bull., 1914 : 338. This plant is a *Gladiolus*, and as the name *speciosa* has already been used under that genus, I change it to *Gladiolus aberdaricus* N. E. Br., nom. nov.

A. sudanica Chev., Expl. Bot. Afr. Occ. Franc., 1 : 634. Name only ; this is a species of *Gladiolus* closely allied to, if not the same as, *G. labiatus* N. E. Br.

A. Thonneri De Wild., Étud. Fl. Bangala and Ubangi, 208 = *Gladiolus Thonneri* Vaupel.

Key to genera hitherto included in Antholyza.

N.B.—All the genera enumerated and characterised below are distinguished from *Gladiolus* and its allies by the tube of the flower being truncately contracted or abruptly narrowed near or below the middle into a slender basal part. In *Gladiolus* and its allies the tube gradually tapers from apex to base without any abrupt narrowing.

a. Stem bearing one dense, sessile lateral spike near its base and continued beyond it as a naked stem with some barren bracts or rarely one flower at its apex; flower 2-lipped, much compressed at the mouth of the tube and the lips nearly equal in length and widely gaping, 1–2 inches long . . . . . *Antholyza.*

a. Stem always ending in a lax or dense spike of flowers and simple or branched, *b.*

b. Stem with 2–4 dense, sessile, lateral spikes and a terminal one; flowers 2-lipped, not much compressed at the mouth of the tube; lips not widely gaping and not more than 12–16 mm. long . . . . . *Anaclanthe.*

b. Stem always paniculately branched, the spikes not sessile, but having a very conspicuously zigzag axis and many flowers; leaves 2·5–7·5 cm. broad; bracts equal, 4–7 mm. long, many times shorter than the flowers . . . *Curtonus.*

b. Stem sometimes branched in the genera *Chasmanthe* and *Kentrosiphon*, in all others unbranched and bearing only one terminal spike; the axis is sometimes slightly flexuose but never conspicuously zigzag, *c.*

c. Upper lobe of flower much longer than the other five, differently shaped and concave or hooded, with the stamens under and about equalling or exceeding it, *d.*

d. Tube of the flower with a distinct, short spur or sac in front immediately above the slender basal part; lateral lobes very small directed in a line with the upper lobe, and the three lower lobes much smaller and arising at different levels below the lateral pair . . . . . *Kentrosiphon.*

d. Tube of flower without a spur or sac, *e.*

e. Two lobes belonging to the upper lip of the flower reflexed like wings behind the base of the upper lobe; lower lip obscure, consisting of three very small lobes placed much below the base of the lateral lobes, with the tube slit open above them and two or all of them inflexed into the tube. *Anomalesia.*

e. None of the lobes reflexed like wings behind the base of the upper lobes, and the lateral and three lower lobes all arising at nearly the same oblique level, *f.*

f. Leaves 4-angled and twisted or flat; bracts 2·5–5 cm. long and longer than the slender part and often as long as the whole of the tube of the flower; capsule (only seen in *P. Schweinfurthii*) shorter than the bracts, subglobosely trigonous; seeds compressed subglobose surrounded by a broad wing . . . . . *Petamenes.*

f. Leaves ensiform or linear, not plicate; bracts 8–20 mm. long, rarely half as long as the flower-tube and often shorter than the slender part of it; capsule longer than the bracts, ellipsoid, firm; seeds angular and winged, or compressed smooth and wingless . . . . . *Chasmanthe.*

c. All the lobes of the flower either subequal and similar in form and flat, or unequal, the five lower being gradually smaller, but all similar in form and the upper one not hooded, leaves linear or subulate, *g.*

g. Flower-spike dense, 10–30-flowered; bracts 8–15 mm. long and the inner bract longer than the outer one; ovules 8–12 in a cell *Anapalina.*

g. Flower-spike lax, 1–7-flowered; bracts 2·5–5 cm. long and the outer bract longer than the inner one; ovules 15–40 in a cell *Homoglossum.*

Anaclanthe N. E. Br.

Corm subglobose, very deeply buried in the soil. Leaves radical, linear, acute, plicate. Stem with 1–4 sessile, spreading lateral spikes and a terminal one. Spikes densely many-flowered, with the flowers in two rows on the upper side. Bracts obliquely imbricating, acute, pubescent except at the brown or purplish tips. Flowers obliquely ascending, unequally 2-lipped; tube curved backwards at the middle and dilated above the curve; upper lip of one concave lanceolate lobe; lower lip of five unequal lobes. Stamens under and equalling or longer than the upper lip of the flower, and inserted at the dilation of the tube; anthers sagittate. Style exserted beyond the stamens; style-arms entire, cuneately clavate, papillose only on the obliquely truncate apex. Ovary ellipsoid-oblong, somewhat truncate at the apex, 3-celled, with two ovules in each cell.

The name is derived from the Greek *anaklao*, to bend back, and *anthe*, a flower, in reference to the tube of the flower being bent backwards.

Species 2, of which *A. plicata* N. E. Br. is the type of the genus. Natives of Little Namaqualand, Piquetberg and Clanwilliam Divisions.

1. **A. plicata** N. E. Br., comb. nov.; *Antholyza plicata* Linn, f.; *Babiana Thunbergii* Ker, and Fl. Cap., 6: 114.

2. **A. namaquensis** N. E. Br., sp. nov. Leaves 15–35 cm. long, 3·5–7 mm. broad, linear, acute, plicate, puberulous between the nerves. Stem 20–35 cm. long above ground, densely and softly villous. Spikes 5–14 cm. long, densely many-flowered in two rows along the upper side. Bracts 2–3 cm. long, 6–12 mm. broad, oblong, very acute, with a hard, needle-like, dark-brown point, pubescent except at the apex. Tube of the flower 3·5–4 cm. long, bent backwards at the middle and dilated above the curve; upper lip about 15 mm. long and 5–6 mm. broad, concave; lower lip of five unequal lobes 8–9 lines long, the two lateral 6–7 mm. broad, reflexed, flat, lanceolate, acute, and the three middle lobes concave and somewhat spathulate-lanceolate, subobtuse.

Cape Province: Little Namaqualand; sand dunes near Port Nolloth, *Bolus* in Herb. Norm. Afr. Austr., 699 (the type); Witbank, *Pillans* 5214!, without precise locality, *Scully* 222!.

This plant is very similar to *A. plicata*, but differs by its bracts being more numerous and more crowded, much broader and far more acute than those of *A. plicata*, in which they are only 5–8 mm. broad, much obtuse, and have a much shorter pubescence.

Curtonus N. E. Br.

Corm subglobose. Leaves basal, very broad, ensiform or lanceolate. Stem stout, paniculately branched; branches ending in a spike, with zigzag axis and many flowers. Bracts equal, 2–3 lines long, obtuse. Flower-tube curved and sharply narrowed below the middle into a slender part; lobes unequal, narrowly oblong or linear-oblong, the upper one longer than the other five, concave. Stamens about as long as and immediately under the upper lobe; two of them inserted near, and the other one at the base of, the dilated part of the tube. Ovary scarcely twice as long as broad, ovoid, with 8–10 ovules in each cell. Fruit not seen.

The name is derived from the Greek *kurtos*, bent, and *onos*, axis, in reference to the zigzag axis of the flower-spike.

The only species is **C. paniculatus** N. E. Br., comb. nov.; *Antholyza paniculata* Klatt, Fl. Cap. 6: 168. A native of the Transvaal and Natal.

Anomalesia N. E. Br.

Corm small, globose, producing stolons ending in a corm. Leaves radical and cauline, linear. Stem unbranched, with a terminal spike of 4–10 flowers. Bracts 1–1½ in. long, herbaceous, the outer longer than the inner. Flower-tube curved, contracted below into a slender basal part, without a spur; lobes very unequal, the upper one much longer than the other five, spathulate, hooded; the two lateral elliptic and reflexed like wings behind the base of the upper lobe; the lower three very small and seated some distance below the two lateral lobes and sometimes inflexed into the tube. Stamens nearly as long as and close under the upper lobe; two of them inserted at about the level of the base of the three lower lobes of the flower, the third at the base of the dilated part of the tube, and with a ligule-like or crest-like organ in front of its base; anthers sagittate. Style-arms cuneately clavate, entire. Capsule ellipsoid, shorter than the bracts. Seeds many in each cell, flat and thin, broadly winged all round.

The name is derived from the Greek *anomales*, irregular or unequal, in allusion to the very unequal lobes of the irregular flower. Species 2, natives of South Africa, of which *A. cunonia* is the type of the genus.

A. cunonia N. E. Br., comb. nov.; *Antholyza cunonia* Linn., Fl. Cap., 6: 168; *A. coccinea* Spreng; *Cunonia antholyza* Mill.; *Anisanthus cunonia* Sweet; *Gladiolus cunonia* Ker.

As both *Cunonia* of Miller and *Anisanthus* of Sweet are antedated by other genera with the same names, it has been necessary to propose a fresh generic name as above.

A. splendens N. E. Br., comb. nov.; *Anisanthus splendens* Sweet, Brit. Fl. Gard., ser. 2, t. 84; *Antholyza splendens* Steud; *Gladiolus splendens* Herb. This is exceedingly like *A. cunonia*, but seems to differ distinctly by the middle lobe of the lower lip of the flower being much longer, recurved-spreading and scarlet at the apex, instead of being small and inflexed into the tube, and so quite concealed from view as it is in *A. cunonia*. It is also apparently a much taller plant, as Sweet describes it as being "2–3 feet high." I have not seen any specimen that corresponds to the figure given by Sweet.

Baker (Fl. Cap., 6: 166) refers *Anisanthus splendens* Sweet to *Antholyza caffra*, to which plant it bears no resemblance.

Kentrosiphon N. E. Br.

Corm somewhat conical, with fibrous coats. Leaves several, cauline, linear. Stem simple or branched, with 1–4 spikes of 3–9 flowers. Bracts 8–15 lines long, herbaceous, subequal or the outer longer than the inner. Flower-tube slightly curved forward with a short spur or sac in front at the place where it is constricted into a slender basal part; lobes very unequal, the upper lobe very much longer than the others, spathulate, concave or hooded, with two very small lateral lobes directed in a line with it at its base, and the other three much smaller and arising at different levels below the lateral pair. Stamens nearly as long as and close under the upper lobe, one arising at the base of the opening to the spur, and the other two a little higher up the tube; anthers sagittate. Style-arms narrowly cuneate, entire. Capsule ellipsoid, shorter than the bracts. Seeds many in a cell, flat, broadly winged all round.

The name is derived from the Greek *kentron*, a spur, and *siphon*, a tube; the tube of the flower has a short blunt spur or sac.

Species 4, native of South Africa, of which *K. saccatus* N. E. Br. is the type of the genus.

This genus is nearly related to *Anomalesia*, but differs conspicuously by the presence of a spur and the different arrangement of the lobes of the flower.

K. saccatus N. E. Br., comb. nov.; *Anisanthus saccatus* Klatt; *Antholyza saccata* Bak., Fl. Cap., 6: 168.

K. Steingroveri N. E. Br., comb. nov.; *Antholyza Steingroveri* Pax, Bot. Jahrb., 15 : 156. Great Namaqualand.

K. propinquus N. E. Br., sp. nov. Plant 100 cm. or more high. Leaves several to a stem, the three basal reduced to sheaths thickly spotted with white on a dark ground; the other, 18–40 cm. long and 5–10 mm. broad, linear, acute. Inflorescence, with 1–2 branches and 5–10 flowers to a spike. Bracts about 2 cm. long, somewhat obtuse. Flower-tube slightly curved forward, with a blunt spur 4 mm. long; lateral lobes about 1 cm. long and 3 mm. broad, somewhat obliquely rhomboid-ovate, shortly and abruptly acute at the front margin; the 3 lower lobes 1–2·5 mm. long, inflexed into the tube; the upper and lateral lobes appear to have been carmine-coloured and the three lower lobes perhaps green.

Cape Province: Van Rhynsdorp Division; Kneghts Vlagte, *Schlechter* 8163 !.

This is closely allied to *K. saccatus*, but the flowers seem to be different in substance and colour, while the lateral lobes are very different in shape, and twice as broad as those of *K. saccatus*, and it is native of a different locality.

K. gracilis N. E. Br., sp. nov. Probably 30 cm. or more high, but only an imperfect specimen seen; probably glaucous. Leaves 25–35 cm. long, 1·5–2·5 mm. broad, linear, acute. Inflorescence apparently unbranched. Bracts 15–20 mm. long, acute or subobtuse and apiculate. Flower 3·5–4 cm. long; tube nearly straight, being very slightly curved forward above the very small saccate spur, which is only about 0·5 mm. long; upper lobe about 2·5 cm. long, spathulate hooded, stated to be "bright red" and appearing to be scarlet red; the two lateral lobes about 4 mm. long and 1·5 mm. broad, lanceolate, acute, the other three smaller, acute, and apparently green. Fruit not seen.

South-West Africa: at Otjiwarongo, on a stony kopje, *Bradfield* 560 !.

K. Duftii N. E. Br., comb. nov.; *Antholyza Duftii* Schinz., in Mem. Herb. Boiss., No. 20, p. 13.

Chasmanthe N. E. Br.

Corms subglobose, superposed one upon another. Leaves basal and cauline, linear or ensiform. Stem simple or occasionally with 1–2 branches ending in a spike of 5–25 flowers. Bracts 4–9 lines long, rarely half as long as the flower-tube and often shorter than the slender part of it, subequal or the inner slightly longer than the outer one, firm. Flower-tube curved, and near or below the middle contracted into a slender basal part, without a spur or sac; lobes unequal; upper lobe spathulate, slightly hooded and much longer than the other five lobes, which arise close together, are similar in form, and are not very unequal among themselves, spreading.

Stamens under the upper lobe of the flower and about as long as it, two inserted near or below the middle and one at the base of the dilated part of the tube, or all three inserted there. Capsule angular and winged or compressed, smooth and wingless.

The name is derived from the Greek *chasme*, gaping, and *anthe*, a flower, in allusion to the shape of the flower.

Species 9, all natives of South and South-West Africa. The type of the genus is *C. aethiopica* N. E. Br.

C. caffra N. E. Br., comb. nov.; *Antholyza caffra* Baker, not of Ker.

Great confusion has been caused by the adoption of the name *Antholyza caffra* Ker for this plant. Ker's name was founded upon a different species, which bore a mere manuscript name in the Banksian Herbarium; no description of it was ever published by Ker or any other person until Baker described it under the name of *A. intermedia*; as that is the first description published of the plant, that name must be maintained for it, and the manuscript name, *A. caffra* Ker (not of Baker), placed as a synonym of it.

As Baker's description of *A. caffra* in his Handbook of Iridaceae, p. 230, is the first description published under that specific name, the plant that is so described must bear the name *A. caffra* Baker (not *A. caffra* Ker), and must be retained as above emended for the plant now well known in South Africa and elsewhere as *A. caffra*. But the synonyms *Anisanthus splendens* Sweet and *Gladiolus splendens* Herb., quoted under *A. caffra* by Baker, belong to a totally different plant, *Anomalesia splendens* N. E. Br.

C. bicolor N. E. Br., comb. nov.; *Antholyza bicolor* Gasp., Belg. Hort., 2: 145, fig. 1; *A. aethiopica* var. *minor* Lindl.

C. intermedia N. E. Br., comb. nov.; *Antholyza intermedia* Baker, in Fl. Cap., 6: 166; *A. caffra* Banks ex Ker, name only, no description; see note under *C. caffra* N. E. Br.

C. aethiopica N. E. Br., comb. nov.; *Antholyza aethiopica* Linn.; Fl. Cap., 6: 167; *A. immarginata* Thunb. ex Baker, as to sheet B of Thunberg's Herbarium (not as to sheet A). The typical *C. aethiopica*, as represented by the type of *Antholyza aethiopica* in the Linnean Herbarium, and by Cornuti's figure which he quoted, is the plant having rather narrow leaves and a truncate base to the dilated part of the flower-tube. *Bolus* 4747 from Devil's Peak may be taken as representing this species; it has not been distinguished by Baker and South African botanists from *C. vittigera*, which also has a truncate base to the dilated part of the flower-tube, but has much broader leaves; or from *C. floribunda* which has the dilated part narrowed into the slender part of the tube and much broader leaves. As dried material of these three plants can easily be separated they are here retained as distinct species.

C. Peglerae N. E. Br., sp. nov. Plant apparently about 45–50 cm. high.

Leaves 15–30 cm. long, 15–22 mm. broad, ensiform, acute. Stem simple. Spike about 9 cm. long, unilateral, with 12–15 flowers. Bracts 8–10 mm. long, 7–8 mm. broad, the outer elliptic or suborbicular when flattened out, very obtusely rounded at the apex, purplish. Flowers 5·5–6 cm. long, much curved ; tube with the dilated part truncately contracted into the slender basal part ; upper lobe 25–28 mm. long and 4 mm. broad in the folded state when dried, spathulate, hooded ; the other five lobes 8–10 mm. long, oblong, obtuse ; the front part of the tube of the flower appears to have been yellowish and all the other parts dark red. Capsule about 13 mm. long, ellipsoid, rounded at the apex and longer than the bracts, but immature, and the seeds not ripe.

Cape Province : Kentani Division ; in marshy ground near Black Rock Cove, *Pegler* 500 !.

This species is nearly allied to *C. vittigera*, but is easily recognised by its very obtuse or almost truncately rounded bracts.

C. floribunda N. E. Br., comb. nov. ; *Antholyza floribunda* Salisb. in Trans. Hort. Soc. Lond., 1 : 324 (1812) ; *A. praealta* Redoute (1813) ; *A. ringens* Andr., Bot. Rep., t. 32, not of Linn. ; *A. aethiopica* Andr., not of Linn. ; *A. immarginata* Thunb. ex Baker (as to sheet A of his Herbarium, not as to sheet B) ; the name was never published by Thunberg.

This is totally different from *C. aethiopica*, with which it was united by Baker, both in its very much broader leaves and in the manner in which the dilated part of the flower-tube tapers or rounds off into the slender part instead of being truncately contracted into it. Salisbury founded the species on the plant figured in Bot. Mag., t. 561. I take as my type of this species specimens gathered on Lion Mountain by Mr. Pappe, and near Cape Town by MacOwan (Herb. Austr. Afr., 1549).

C. fucata N. E. Br., comb. nov. ; *Antholyza fucata* Baker in Fl. Cap., 6 : 167 ; *Tritonia fucata* Herb.—This species differs from all the others by the spike being bent at an angle to the stem, as in the genus *Freesia*.

C. vittigera N. E. Br., comb. nov. ; *Antholyza vittigera* Salisb. in Trans. Hort. Soc. Lond., 1 : 324 ; *Antholyza aethiopica* var. B, Ker in Bot. Mag., t. 1172, excluding other synonyms.

C. spectabilis N. E. Br., comb. nov. ; *Antholyza spectabilis* Schinz in Mem. Herb. Boiss., No. 20, p. 13.

Anapalina N. E. Br.

Corm subglobose, with fibrous coats. Basal leaves ensiform or linear with very conspicuous veins or nerves ; stem leaves subulate or very much reduced. Stem unbranched ending in a dense spike of 10–30 flowers. Bracts 4–8 lines long, and the inner bract much longer than the outer one,

firm. Flower-tube curved, and near or below the middle contracted into a slender basal part; lobes subequal, obliquely placed, the upper one directed forward and the others more or less recurved-spreading, not overlapping. Stamens exserted, inserted at the base of the dilated part of the tube. Ovary ovoid, scarcely, or not twice, as long as broad, with 8–12 ovules in a cell. Capsule 2–3 times as long as the bracts, ellipsoid. Seeds flattened, winged all round.

The name is derived from the Greek *anapalin*, in reversed order, in reference to the inner bract being longer than the outer one.

Species 4, all natives of South Africa, *A. triticea* N. E. Br. being the type of the genus.

A. triticea N. E. Br., comb. nov.; *Ixia triticea* Burm. (1768); *Antholyza triticea* N. E. Br. in Kew Bull., 1929: 136; *Antholyza lucidor* Linn. f. (1781); *Watsonia lucidor* Eckl.; *Homoglossum lucidor* Baker; *Gladiolus lucidor* Baker.

A. revoluta N. E. Br., comb. nov.; *Antholyza revoluta* Burm. (1786); *Antholyza nervosa* Thunb. (1803); *Antholyza spicata* Brehm.; *Gladiolus nervosus* Baker.

As I have stated in Kew Bull., 1929: 131, there is no specimen now in Burmann's Herbarium of *Antholyza revoluta* Burm., but his description (" staminibus adscendentibus, corollis revolutis, foliis lanceolatis nervosis; 1757 mense Octobri floruit, scapus sesquipedalis teres, flores purpurei ") seems so clearly to indicate this plant that there can scarcely be a doubt as to the correctness of this identification of it with *Antholyza nervosa* Thunb., as its lanceolate, prominently nerved leaves, revolute lobes, and colour of the flower so precisely agree with Burmann's description.

The plant called *Antholyza revoluta* by South African botanists is a species of *Homoglossum* and does not in any way agree with Burmann's description of that species.

By the courtesy of Dr. L. Diels, Director of the Berlin Botanic Garden, I have had the privilege of being able to compare the type of *Antholyza spicata* Brehmer with the Kew material, and find that it is identical with specimens of *Anapalina revoluta* distributed by Drège under the name " *Antholyza nervosa* Th. a," the number for which on Drège's original label is 1576; it was collected at Du Toits Kloof. The leaves of the type of *A. spicata* have the peculiarity of having only 3–4 nerves, but I find specimens from other localities that sometimes (but apparently rarely) have the same reduced number instead of the more usual 4–5 nerves.

A. Burchellii N. E. Br., comb. nov.; *Antholyza Burchellii* N. E. Br., in Kew Bull., 1929: 136, 137.

A. pulchra N. E. Br., comb. nov.; *Homoglossum pulchrum* Schlechter, in Engl. Jahrb., 24: 453; *Antholyza pulchrum* Baker.

PETAMENES Salisb. ex N. E. Br.

Corm subglobose, with fibrous coats. Leaves cauline, varying from subulate to ensiform. Stem unbranched. Spike two to many-flowered, secund. Bracts 3–8 cm. long, herbaceous, the outer much longer than the inner. Flower-tube curved, narrowed near or below the middle into a slender basal part, the lobes very unequal, the upper one much longer and larger than the others, concave or hooded ; the other five directed forward, and the two laterals much larger than the three lower lobes. Stamens about as long as the upper lobe of the flower and close under it, all inserted at the base of the dilated part of the tube. Style-arms cuneate and stigmatose at the apex. Capsule much shorter than the bracts, ellipsoid, with numerous seeds in each cell. Seeds flattened, winged all round.

Species 9. Natives of South and Tropical Africa. The type of the genus is *P. abbreviatus* N. E. Br.

Petamenes was founded by Salisbury without a description, upon the plant figured as *Gladiolus quadrangularis* Ker, in Bot. Mag., t. 567 (1802), and *G. abbreviatus* Andr., Bot. Rep., t. 166 (1801). And Salisbury named the plant *Petamenes quadrangularis* because Ker had supposed it to be the same as *Antholyza quadrangularis* Burm. This, however, was quite a misidentification, as Ker never saw Burmann's type. Therefore I propose to retain the name *P. abbreviatus* for this plant, as that name was published a year earlier than Ker's misidentification of it, placing *P. quadrangularis* Salisb. as a synonym of that name, and referring *Antholyza quadrangularis* Burm. to the genus *Homoglossum*, where it more correctly belongs.

The South African Species are :

P. abbreviatus N. E. Br., comb. nov. ; *Gladiolus abbreviatus* Andr., Bot. Rep., t. 166 ; *Antholyza abbreviata* Pers ; *Gladiolus quadrangularis* Ker ; *Petamenes quadrangularis* Salisb. ; *Antholyza quadrangularis* Baker, not of Burmann ; *Anisanthus quadrangularis* Klatt.

P. Guthriei N. E. Br., comb. nov. ; *Antholyza Guthriei* L. Bol., in Ann. Bol. Herb., 3 : 12. Not seen by me, but as it is stated to be " very closely allied to *Antholyza quadrangularis* Burm." (by which is meant not Burmann's plant, but *P. abbreviatus* as above quoted), I place it here.

P. Buckerveldii N. E. Br., comb. nov. ; *Antholyza Buckerveldii* L. Bol., in Ann. Bol. Herb., 4 : 118. This species is stated to have a flower-spike 2 feet (60 cm.) long. I have not seen it.

The Tropical African Species are :

P. huillensis N. E. Br., comb. nov. ; *Antholyza huillensis* Welw., in Trans. Linn. Soc., ser. 2, 1 : 270.

P. zambesiacus N. E. Br., comb. nov.; *Antholyza zambesiaca* Baker, Handb. Irid., 232; *A. magnifica* Harms in Warb. Kunene-Zamb. Exped., 201.

N.B.— *A. zambesiaca* was founded upon a mixture of leaves of *Vellozia*, part of the stem of some iridaceous plant, and flowers that are unquestionably the same as those of *A. magnifica* Harms. So that the description given by Baker is a composite one and the plant cannot be identified from it. But as the flowers proclaim its identity with *A. magnifica*, I deem it best to retain the older name for the plant.

P. Degasparisianus N. E. Br., comb. nov.; *Antholyza Degasparisiana* Buscal. and Muschler, in Engl. Bot. Jahrb., 49: 463.

P. latifolius N. E. Br., nom. nov.; *Antholyza abyssinica* Baker, Fl. Trop. Afr., 7, 375, not of Brongniart.

To this species belong the plant with lanceolate acuminate bracts collected at Hedja, *Schimper*! and *Schimper* 1206!. The true *Antholyza abyssinica* Brongn., with obovate acute bracts as long as the flowers, is *Oenostachys abyssinica* N. E. Br.

P. schweinfurthii N. E. Br., comb. nov.; *Antholyza schweinfurthii* Baker, in Gard. Chron., 1894, 15: 588.

Homoglossum Salisb.

Corm subglobose, with the lower part of the coats split into fibres or narrow segments. Leaves few, subulate or linear. Stem unbranched, ending in a lax spike of 1–8 flowers. Bracts 1·5–6·5 cm. long, the outer longer than the inner, herbaceous. Flower-tube curved and near or below the middle contracted into a slender basal part; limb oblique, with broad lobes, regularly arranged and sometimes overlapping, subequal or not very unequal, but the dorsal one rather larger than the others. Stamens inserted much below the middle or at the base of the dilated part of the tube. Capsule shorter than the outer bract. Seeds numerous (ovules in the ovary 15–40) in each cell, flat, winged all round.

Species about 10, natives of South and Tropical Africa. The type of the genus is *H. Watsonianum* N. E. Br.

The genus *Homoglossum* was founded by Salisbury (without a description) in Trans. Hort. Soc. Lond., 1: 325, upon the plant figured in Andrews, Bot. Rep., t. 38 (1798), as *Gladiolus praecox*, and named *Homoglossum praecox* Salisb., but as that plant is identical with *Gladiolus Watsonius* Thunb. (1784), the latter specific name must take precedence. As I have pointed out in Kew Bull., 1929: 244, the specific name "Watsonius" is obviously an error, which Pax has already changed to "Watsoniana," under the genus *Antholyza*, but as it might with equal right be changed

to " Watsonii," as it was probably named after Dr. William Watson, to whom Miller dedicated the genus *Watsonia*; and as the name " *Gladiolus Merianus* " Thunb. (named after Madame Merian) is of the same character, it would appear better to retain the names as Thunberg had them, unchanged.

In 1866 an unfinished description of the genus *Homoglossum* was published in Salisbury, Genera of Plants, p. 143.

Tropical African Species.

H. Watsonioides N. E. Br., comb. nov.; *Gladiolus Watsonioides* Baker; *G. Garnierii* Klatt, in Bot. von Ost-Afr. (Decken's Reisen), 73, not of Linnaea, xxxvii: 511; *Antholyza Watsonioides* Baker, in Fl. Trop. Afr., 7: 376.

N.B.—I have not seen a specimen of the true *Gladiolus Garnierii* Klatt, which is a native of Madagascar, so do not know if it belongs to this genus, or is a true *Gladiolus*. According to description it has much longer flowers than *H. Watsonioides* N. E. Br.

H. gracile N. E. Br., comb. nov.; *Antholyza gracilis* Pax in Engl. Hochgebirgsfl., 177; *Gladiolus Watsonioides* var. *minor* Baker.

South African Species.

H. Watsonium N. E. Br., comb. nov.; *Gladiolus Watsonius* Thunb. (1784), not of Bolus; *G. praecox* Andr., Bot. Rep., t. 38 (1798); *Homoglossum praecox* Salisb.; *H. revolutum* Baker; *Antholyza revoluta* Baker, in Fl. Cap., 6: 169, not of Burm.; *Watsonia praecox* Pers.

H. acuminatum N. E. Br., comb. nov.; *Antholyza acuminata* N. E. Br., in Kew Bull., 1929: 133; *Gladiolus recurvus* Houtt., not of Linn.

H. Gawleri N. E. Br., comb. nov.; *H. revolutum* var. *Gawleri* Baker, in Journ. Linn. Soc.; *Antholyza Gawleri* L. Bol., in Ann. Bol. Herb., 3: 11; *Gladiolus Watsonius* vár. *B*, Ker in Bot. Mag., t. 569. See note under *H. Huttoni*.

H. Huttoni N. E. Br., sp. nov.—Plant 30–60 cm. high. Leaves 1–2 to a plant, equalling or shorter than the stem, 20–45 cm. long, 1·5–2 mm. thick, subulate, sulcate. Spike laxly 2–3-flowered. Bracts 3–5 cm. long, appearing acute or acuminate, but when flattened out more or less obtuse with a short point at the apex. Flower 7–8 cm. long, stated to be of a " lovely crimson, throat streaked with a yellowish tinge "; tube curved, narrowing at about the middle into a slender basal part; limb oblique with the lobes more or less overlapping and directed forward, somewhat unequal, the upper lobe 3·5–4 cm. long, and 16–18 mm. broad, elliptic-

ovate, and the middle lower lobe 2–2·5 cm. long and 5–6 mm. broad, lanceolate, all acute or shortly acuminate.

ALBANY DIVISION: near Grahamstown, *MacOwan*!, *Galpin* 66!; Albany district: *Hutton* (the type); Eastern Frontier, *Barber*!. East London Division: near East London, *Mason*!.

N. B.—This plant has been named by Mrs. Bolus on Herbarium sheets, "*Antholyza Gawleri*, L. Bolus," and no doubt is widely known in South Africa under that name. But the true *H. Gawleri* (founded on the figure in Bot. Mag., t. 596) is a very much dwarfer plant than *H. Huttoni*, with flat, linear-lanceolate (not subulate) leaves 5–7 mm. broad; the lobes of the flower separate, subequal, all lanceolate and acuminate, with the basal half of all of them as well as the throat and tube streaked and spotted with scarlet-red on a yellow ground.

H. Priorii N. E. Br., comb. nov.; *Antholyza Priorii* N. E. Br., in Kew Bull., 1929: 244; *A. Watsonius* L. Bol.; *Gladiolus Watsonius* Bolus and Marloth, Fl. Pl. S. Afr., vi: t. 240, not of Thunb. See Kew Bull., 1929: 243.

H. flexicaule N. E. Br., nom. nov.; *Gladiolus Watsonius* Jacq., Collect., iii: 257, and Ic., t. 233, not of Thunb.

This species is well figured by Jacquin, and seems to be rare, but was collected by Villett without indication of locality. It differs from *H. Watsonium* by the linear leaf much overtopping the flower-spike, which is bent nearly at a right angle to the lower part of the stem as in the genus *Freesia*, and by the narrower, lanceolate, acute lobes of the flower.

H. Merianellum Baker, in Journ. Linn. Soc., 16: 1; *Gladiolus Merianellus* Thunb.; *Watsonia pilosa* Klatt.

H. caryophyllaceum N. E. Br.; *Antholyza caryophyllacea* Burm. Burmann's type specimen, apart from colour, is correctly figured in Houtt., Handleid., xii: 63, t. 79, f. 3. See Kew Bull., 1929: 130.

H. Muirii N. E. Br., comb. nov.; *Antholyza Muirii* L. Bol., in Ann. Bol. Herb., 3: 12.

H. Fourcadei N. E. Br., comb. nov.; *Antholyza Fourcadei* L. Bol., in Ann. Bol. Herb., 4: 117.

H. quadrangularis N. E. Br., comb. nov.; *Antholyza quadrangularis* Burm., Fl. Cap. Prod., 1, not of Baker, in Fl. Cap., 6: 116.

OENOSTACHYS Bullock.

This genus was founded upon a single species, but I find that another species must be added to the genus, so that it will now consist of the following:

O. dichroa Bullock, in Kew Bull., 1930: 466.—Uganda.

O. abyssinica N. E. Br., comb. nov.; *Antholyza abyssinica* A. Brongn., in Richard Fl. Abyssin., 2 : 306, not of Baker.—Abyssinia.

N. B.—The plant actually described by Baker as *Antholyza abyssinica*, in Fl. Trop. Afr., 7 : 373, is entirely distinct from that described by Brongniart under that name, although confused with it by Baker among the specimens enumerated. See *Petamenes latifolius* N. E. Br.

PERCEPTUAL TESTS OF "GENERAL INTELLIGENCE" FOR INTER-RACIAL USE.*

By MEYER FORTES, M.A., Ph.D.

(Psychological Laboratory, University College, London).

(Communicated by Professor H. A. REYBURN.)

Verbal tests of "Intelligence" at the present time still have the greatest vogue and are by far the best validated; yet, ever since Binet first drew attention to it (1), it has been a commonplace that they are not wholly independent of scholastic training and even cultural background. This has been specially emphasised in the United States, where workers in the field were early confronted with the task of testing immigrant children or adults, often ignorant of English. Numerous efforts have therefore been made to circumvent this difficulty by the construction of non-verbal tests. Manipulative tests of the form-board and block-construction kinds were first resorted to (2). Subsequently, at the historic testing of the American army, it became necessary to devise a means of testing illiterate and immigrant soldiers in groups, and the Army Beta Test resulted (3). This, like most pencil-and-paper non-verbal tests emanating from America, consists in the main of graphic analogues of verbal or performance tests already in use—translations of these, as it were. The most recent and most ambitious of such non-verbal tests known to me is S. C. Dodd's "International Group Test" (4). Dodd aimed at a test which could be used regardless of differences of race, culture, education, or training—in fact, a "universal" test. To this end he assembled lists of presumably universal phenomena, such as "humans in varying situations," animals and utensils most widely known, etc. These were then utilised in the construction of a number of tests, such as an "Association" test, a "Matching" test, a "Narrative" test, and so on.

The main criticism one has to urge against Dodd's work is that it does not dispose of the crucial difficulty which non-verbal tests are intended to

* From a paper read at a meeting of the British Psychological Society, London, on 13th December 1930, being an abstract of a thesis accepted for the degree of Ph.D. in the University of London. The writer is indebted to Professor C. Spearman for guidance during the course of the research.

solve. It does not eliminate the influence of differential past experience, for the pictures require interpretation before they can be dealt with, and this is a matter of associative reproduction plus supplementation. With the present-day wide discrepancies in environment and upbringing of different classes and races, it is highly questionable whether identical reproductions would occur in different groups of people. Moreover, this difficulty defies solution as long as Thorndike's (5) segmentational theory of the nature of "Intellect" and his insistence on the impossibility of measuring native intellect save by means of tasks equally familiar to all testees are adhered to—views which seem to dominate American work in this field. On these views, one is committed to empirically discovering suitable test material, as well as to empirically exploring which segments of intellect anything can be predicted about on the basis of achievement in the test concerned. A new approach to the problem seems to be called for, and it is this that I have attempted.

The foundation and starting-point of my work was not direct empirical observation, but the theories of Two Factors (6) and of Noegenesis (7). Shortly before I commenced my research, Dr. W. Line (8), working upon the problem of the growth of visual perception in children, had made an interesting and important discovery. He had constructed tests of graded relational complexity by means of two-dimensional spatial diagrams, colour patches, and intensity differences. Line's figures and tests were of an extremely simple sort, requiring chiefly the comparison of angles, lines, colours and shades of grey. Reproduction was completely excluded from a critical rôle in the solution of the tests, whereas they were insoluble without the eduction of the relations involved. Line's important discovery was that these tests correlate to the extent of 0·89 (corrected for attenuation) with 'g,' which supports strikingly Professor Spearman's contention that perception and the "higher mental processes" form a functional unity subject to a single system of laws (7). The significance of Dr. Line's discovery was that it indicated the possibility of constructing a test of 'g' involving only perceptual fundaments and relations, and having no recourse to pictorial representation—the possibility, that is, of a genuinely universal test of 'g,' depending solely upon the innate activities of primary sentience and eduction (7), and excluding past experience from a critical rôle; thus disposing once for all of the fundamental defect in such tests as Dodd's. My own work aimed at exploring this possibility extensively, rather than at the construction of a definitive perceptual test of 'g.'

It is to be noted that both the research which led up to it and this possibility itself could only be envisaged from the standpoint of some such theory as that of the Two Factors and its complementary theory of

Noegenesis. On the general factor hypothesis, 'g' comes into play only in the eductive processes and not at all in reproductive processes; and, furthermore, any test of 'g,' in so far as it is saturated with 'g,' measures not a particular segment of intellect having some unspecified relation to other segments of intellect, but the general factor which is common to all segments, and about which something can be predicted on the basis of the score in any adequate 'g' test.

My procedure in constructing my tests differed somewhat from that of Dr. Line. I used only two-dimensional spatial figures, while he had used coloured and grey patches as well. My figures were more complex in form than his, while at the same time, as far as I could judge and plan, demanding no associative reproduction in order to be apprehended in their rôles in the tests; while being, in short, "meaningless" outside of the tests, or requiring no "meaning" to be attached to them before the problems in which they occurred could be solved. Line confined himself to relation eduction, whereas my tests were planned to evoke both relation and correlate eduction, thus, it was hoped, approximating more to the cognitive situations usually met with in life and in 'g' tests, as well as permitting a wider range of difficulty to be achieved.

A survey of the literature suggested a number of forms in which tests such as I had in mind could be cast, six of which were eventually retained. The figures or fundaments used in the tests were obtained by ransacking books of art, architecture, and photography, by adapting scientific diagrams and foreign scripts like Chinese and Egyptian hieroglyphs. In this way several thousand unusual, often bizarre and quite meaningless figures were accumulated, which were modified, adapted, and decomposed to suit my purpose as occasion required. My next step was to collect a large number of concepts embodying different kinds of relations, from dictionaries and compendia, and classify them in categories. Finally, this raw material was built up into six tests. (See Figures.) In this connection the main problem was that of providing in each test a fairly wide and graded range of difficulty. To accomplish this I employed the method of hierarchical complication successfully used by Line, which is based upon Professor Spearman's analysis of the normal development of cognition. By this method the subtests are constructed so that at the easiest level the critical relation—*i.e.* the relation which constitutes the main difficulty and must be apprehended for the problem to be solved at all—is of the first order. At the next level of difficulty the critical relation is of the second order, and so on. At the higher levels difficulty could be enhanced by omitting relations or introducing irrelevant relations in "wrong" figures.

The six tests were assembled separately in booklets for purposes of the experiment. In giving a test, the booklets were distributed to the class

and a demonstration chart pinned to the board. Such charts were constructed for each test. Each chart presents subtests identical in form with those of the corresponding test, but having entirely different fundaments and relations. The procedure was then in each case verbally demonstrated on the chart, which was always removed before the class was allowed to work the test. This method of explaining the tests seemed most suitable to me, since I was especially concerned with determining the scope and value of the test material, rather than with discovering the best technique for administering the tests. It remains for future research to decide whether pantomimic instruction, or some such method as the card-sorting one employed by Line, is more advisable. For the same reason the tests were always given without a time-limit, so as to enable every subject to complete

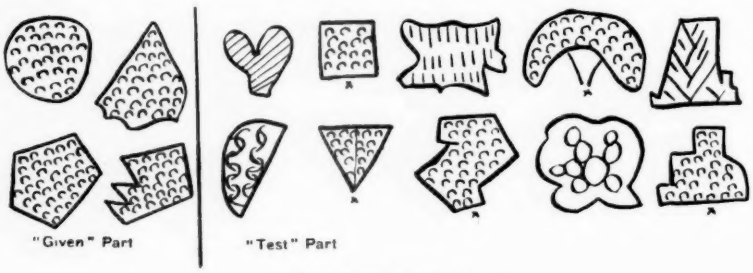


FIG. (*a*).—Test ' F ' I.

all the subtests. The question of speed in tests of this sort is another problem for future research. As a result, it took as much as six or seven hours, distributed over a week, to test a single class.

I shall now briefly describe the tests, which for convenience of notation I have called the ' F ' tests.

Test ' F ' I consists of two parts, the first of which was originally intended to act as a shock-absorber to the series but gave such poor results that it was eventually omitted from the calculations. This first part is adapted from the digit-symbol tests common in America. The testee is required to mark all the figures on the page which are like any of the figures in the top row. The second part, hereafter referred to as test ' F ' I, consists of ten subtests, each on a small page. Each subtest is divided into two parts. On the left of the partition are four figures all alike in some way (this part I call the " given " part) ; on the right are ten other figures (which I call the " test " part). The subject is required to mark all the figures in the " test " part which are like the figures in the " given " part in the same way as these are like one another. That is to say, the subject first has to educe the appropriate likeness-relation mediating between the four

figures on the left, and then find the correlates among the figures on the right. (See fig. (*a*). The crosses indicate the correct "test" figures.)

Test 'F' II consists of three parts, each slightly different from, but yet resembling, the others. In *Part A* each subtest consists of five figures, the one on the left, marked off by a double line, being the "given" figure. The subject is required to select the figure among the four on the right which is most like the "given" one. This, it appears, is done either by relation or by correlate eduction. In *Part B* two figures are given on the left and six on the right, the task remaining the same. In *Part C* two "right"

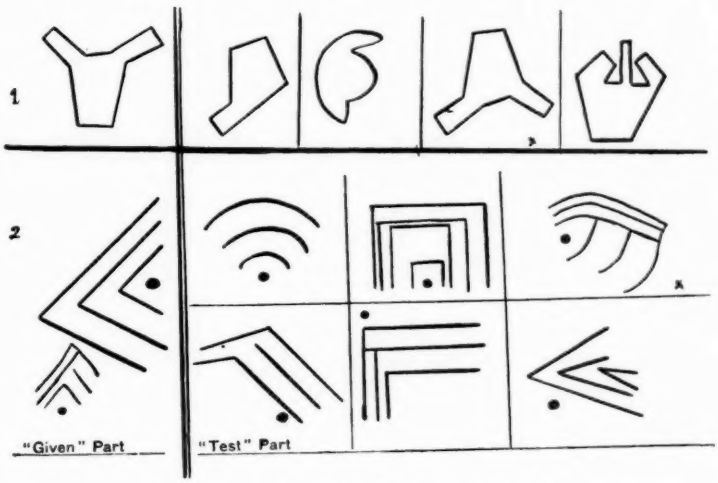


FIG. (*b*).—1. Test 'F' II A. 2. Test 'F' II B.

figures and one "wrong" figure are given on top, and six "test" figures as well, the task being to find the "test" figure most like the two "right" "given" figures. This tripartite division was, of course, purely an experimental device. In parts B and C the testees were told that the additional "given" figures were put there to aid them, as the subtests were more difficult. The need for six "test" figures in parts B and C arose because I found that four figures gave too small a range for selection at the higher levels of difficulty. Correlate eduction appeared to be the process mainly evoked by parts B and C. (See fig. (*b*).)

Test 'F' III.—In this test each subtest consists of six figures. Two of these figures are more closely interrelated than any other pair. The subject is told to mark the pair of figures which belong together best of all. Here

again both correlate and relation eduction were found to be elicited. (See fig. (*c*).)

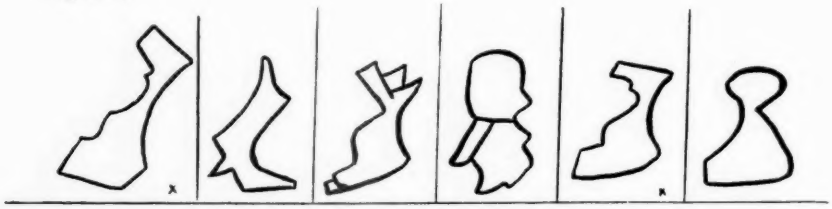


FIG. (*c*).—Test 'F' III.

Test 'F' IV is distinguished from the others in that it is homogeneous throughout as regards the kind of fundaments and relations employed. It is a pattern completion test adapted, as is evident, from form-board tests. The subject is required to find the small pattern among the four or five on the right which will exactly fit into the "aperture" left in the pattern on the left. Two things have to be taken into account—the shape of the aperture and the pattern. Both relation and correlate eduction come into play. (See fig. (*d*).)

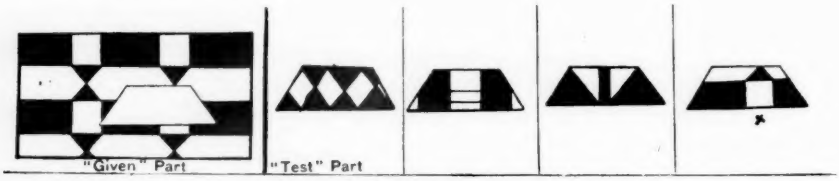


FIG. (*d*).—Test 'F' IV.

Test 'F' V resembles such familiar tests as those of "Narratives" or "Number completion." Each subtest presents only one figure in various stages of change. On the left is given the commencing stage, and on the extreme right the final stage of the series. The testee has to mark, consecutively, the intermediate stages, one in each of the columns. It appears that the solution is achieved by the eduction, first, of a relation of evidence between the beginning and the end stages, and then of correlates in the intermediate stages. Increase of difficulty is produced by multiplying the number of concurrent changes. (See fig. (*e*).)

Test 'F' VI is a rhythm completion test. The "given" part consists of recurring feet of a rhythm, the last foot being purposely left incomplete, thus: a-b-a, a-b-a, a-b-a, a-b-... The "test" part consists of six columns, each with three figures in. The subject is required to complete the rhythm

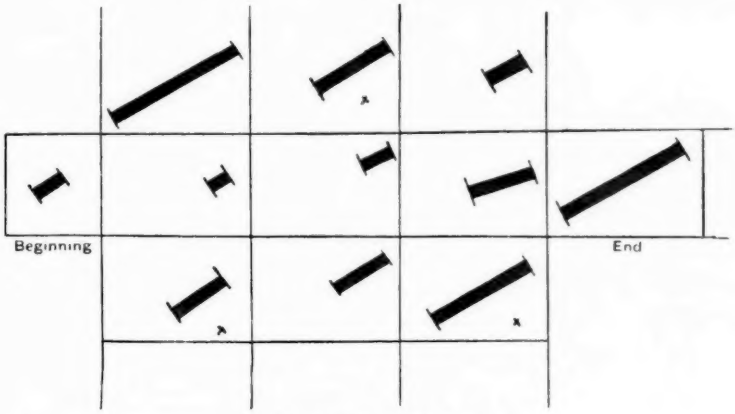
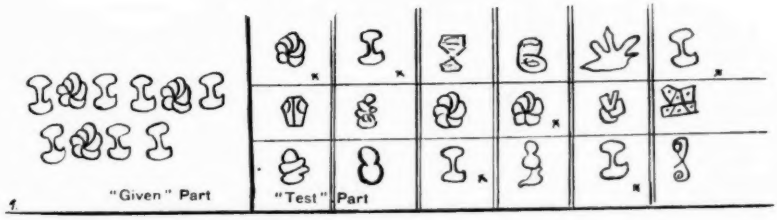


FIG. (*e*).—Test 'F' V.



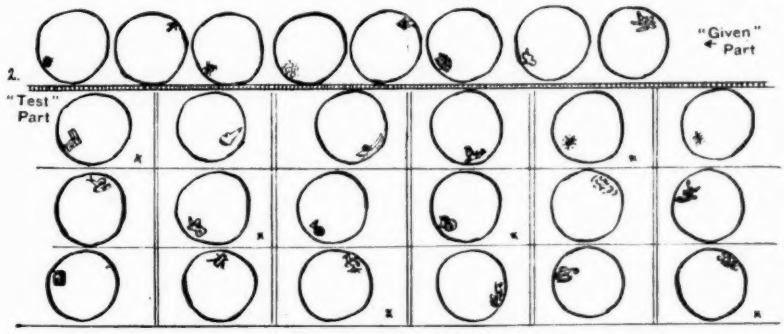


FIG. (*f*).—Test 'F' VI.

1. Easy level, first order.
2. Difficult level, second order.

} Both rhythms 'a-b-a.'

by marking in succession the correct figures in each column. This test exacts complex processes of cognition, involving both relation and correlate eduction. Strange as it may seem, neither 'F' V nor 'F' VI were at all difficult to demonstrate. I should like to draw attention to one point which especially distinguishes this test from similar tests devised, for instance, by Dodd. In Dodd's case, increasing difficulty is achieved by the permutation and combination of larger and larger numbers of first-order relations. In my test, difficulty is increased by raising the order of the relations constituting a given rhythm, though for comparative purposes I have also included a few subtests constructed on Dodd's plan. Thus I have rhythms of first-order relations at the easiest level, then come rhythms of two or three first-order relations together, then rhythms of second-order relations and so on. (See fig. (*f*).)

In addition to the 'F' tests,* all subjects were given a test of arithmetical problems and an abbreviated version of Professor Spearman's "Measure of Intelligence for Use in Schools."

Experimental Results.

In my main experiment I gave the tests to three groups of children numbering altogether about 240. As the results were substantially the same for all the groups, I shall confine myself to an outline of those obtained with the last and largest group of 104, half of whom were girls and half boys. The average age of this group was 12·64 years 12·6 months. The majority were of British parentage, but there were a few Jewish and one or two Italian and German children. At a later stage I shall also deal with some average results.

I have ignored sex differences in my study since Line (8) has shown these to be negligible in the growth of perception, and other workers (*e.g.* Terman (9)) have demonstrated the same for the development of 'g.'

The accompanying tables present the intercorrelations, (*a*) raw, and (*b*) corrected for attenuation, obtained from the group I have mentioned.

To begin with, it was necessary to determine whether the tests measure 'g' and specific factors only, or whether there were any group factors or large specific overlaps present among them. To this end the Tetrad Criterion † developed by Professor Spearman (6) was applied to all the tables

* Experience proved that the most satisfactory order of giving the 'F' tests was as follows: 'F' IV, 'F' I, 'F' II, 'F' III, 'F' V, 'F' VI.

† The Tetrad Criterion states that when the tetrad equation

$$r_{ab} \times r_{pq} - r_{bp} \times r_{aq} = 0$$

(*a*, *b*, *p*, and *q* being any four correlated abilities) "holds throughout any table of correlations, and only when it does so, then every individual measurement of every ability

TABLE I.

Intercorrelations, Raw, N = 104 (Split-half Reliabilities in italics).

	Arith.	Meas.	'F' I.	'F' II.	'F' III.	'F' IV.	'F' V.	'F' VI.	Age.	'g'
Arithmetic .		·449	·234	·435	·380	·269	·373	·443	·319	·583
"Measure" .	·449	*·599*	·442	·331	·325	·342	·472	·452	·139	·640
'F' I . .	·234	·442	*·498*	·483	·433	·324	·416	·416	·194	·630
'F' II .	·435	·331	·483	*·309*	·378	·392	·366	·404	·292	·640
'F' III .	·380	·325	·433	·378	*·485*	·352	·423	·393	·110	·610
'F' IV .	·269	·342	·324	·392	·352	*·561*	·507	·207	·273	·530
'F' V. .	·373	·472	·416	·366	·423	·507	*·780*	·482	·113	·710
'F' VI .	·443	·452	·416	·404	·393	·207	·482	*·814*	·062	·640
Average .	·37	·40	·39	·40	·38	·34	·43	·39	·19	·62

Average P.E. = 0·06.

. . . can be divided into two independent parts" (6, p. 74), the general factor 'g' which is constant for any individual in respect of all the correlated abilities but varies from one individual to another, and the specific factor 's' which varies both from individual to individual and from one ability of an individual to another. The validity of this *mathematical theorem* is now beyond dispute—see *e.g.* Spearman (6) and T. L. Kelly, *Crossroads in the Mind of Man.*

Theoretically, every tetrad difference derived from a correlation table of several variables should be equal to zero to conform to the Criterion; but sampling and other chance errors cause the observed tetrad differences to deviate from zero. The observed distribution of tetrad differences need not necessarily be "normal"—indeed, will probably not be normal; the proof of the theorem is independent of any assumption about the shape of the curve (6 App., and Spearman, *Brit. Journ. Psychol.*, xix, 1928, p. 97). It can, however, be determined whether such an observed distribution is a chance one, or is biassed by overlapping specific factors, since its theoretically expected standard deviation is known (6, formula 16A). The fit of the observed distribution may be checked in the conventional way by noting whether any of the observed tetrad differences are greater than five times the theoretical P.E. (obtained by the usual formula P.E. = ·6745σ), though this is liable to be inaccurate with distributions which are not normal. A strict mathematical test of the agreement between the theoretical and observed sigmas is not

TABLE II.

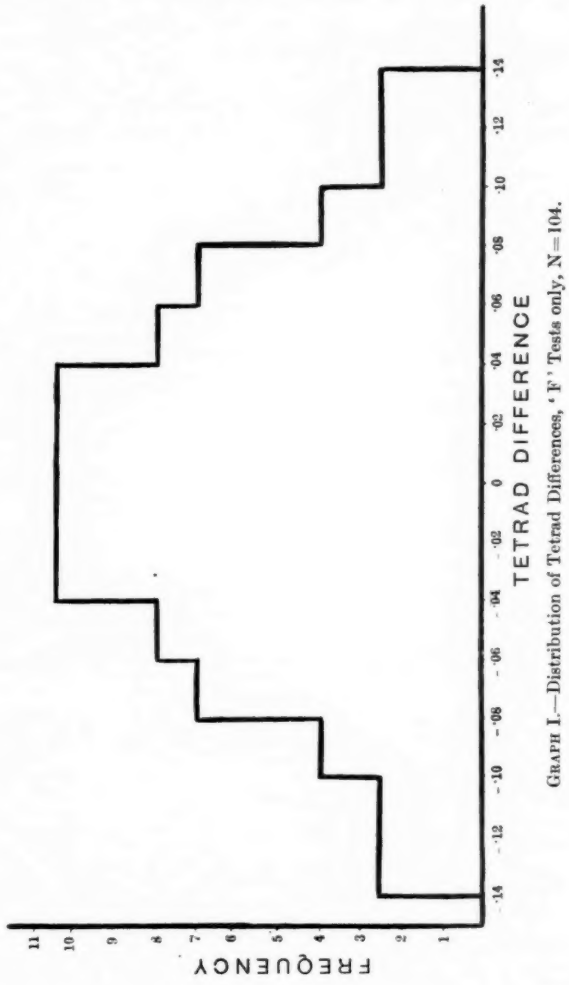
Intercorrelations, corrected for Attenuation, N = 104 (Spearman-Brown Reliabilities in italics).

	Meas.	'F' I.	'F' II.	'F' III.	'F' IV.	'F' V.	'F' VI.
"Measure"	·75	·81	·78	·60	·59	·69	·63
'F' I .	·81	*·66*	1·23	·87	·61	·66	·64
'F' II .	·78	1·23	*·47*	·98	·94	·75	·80
'F' III .	·60	·87	·98	*·65*	·67	·69	·61
'F' IV .	·59	·61	·94	·67	*·72*	·76	·30
'F' V .	·69	·66	·75	·69	·76	*·88*	·59
'F' VI .	·63	·64	·80	·61	·30	·59	*·91*
Average .	·68	·80	·91	·73	·64	·69	·60

available. Pearson (*Biometrika*, Dec. 1927) has proposed a formula for the P.E. of the theoretical sigma of the tetrad-difference distribution, intended to make good this deficiency; but, as Spearman points out in his paper cited above, this formula is disputable. Kelly, discussing this and associated matters, *op. cit.*, pp. 12–14, says: "The obvious way of using the chance standard deviation of a population of tetrad differences would be to compare it with the obtained standard deviation, find the difference between the two and the standard error of this difference. This standard error, which will certainly be very small, is not known, and it probably cannot be determined by any means sufficiently simple to be serviceable."

Yule's formulae for the standard error of sigma (*Introduction to the Theory of Statistics*, 5th ed., p. 351) are, of course, out of the question since they presuppose the "individual cases at issue to be mutually independent, as occurs with successive samples. The tetrad differences are not at all independent of each other, but highly interdependent. They are functions of the same set of values (the correlations) from the same sample." (Professor Spearman, in a letter to the writer.)

of correlations. We may first consider the distribution and dispersion of the tetrad differences obtained from the intercorrelations for the 'F'



GRAPH I.—Distribution of Tetrad Differences, 'F' Tests only, N = 104.

tests only. This is shown for the group I have mentioned, in Table III (*a*) and Graph I. No tetrad difference in this case, it will be noted, is more than five times the probable error of the distribution, and the

observed probable error of the tetrad differences corresponds satisfactorily with the theoretical value. The same results ensue from another table of tetrad differences. This demonstrates that the 'F' tests measure only a general factor and a factor specific to each test. It is necessary, however, to determine whether this general factor is 'g' or is some broad group factor uniting all the 'F' tests. We have therefore to consider the tetrad differences derived from the intercorrelations of the 'F' tests with two reference tests. The "Measure" and the Arithmetic test provide convenient reference tests which previous workers have shown to be suitable for this

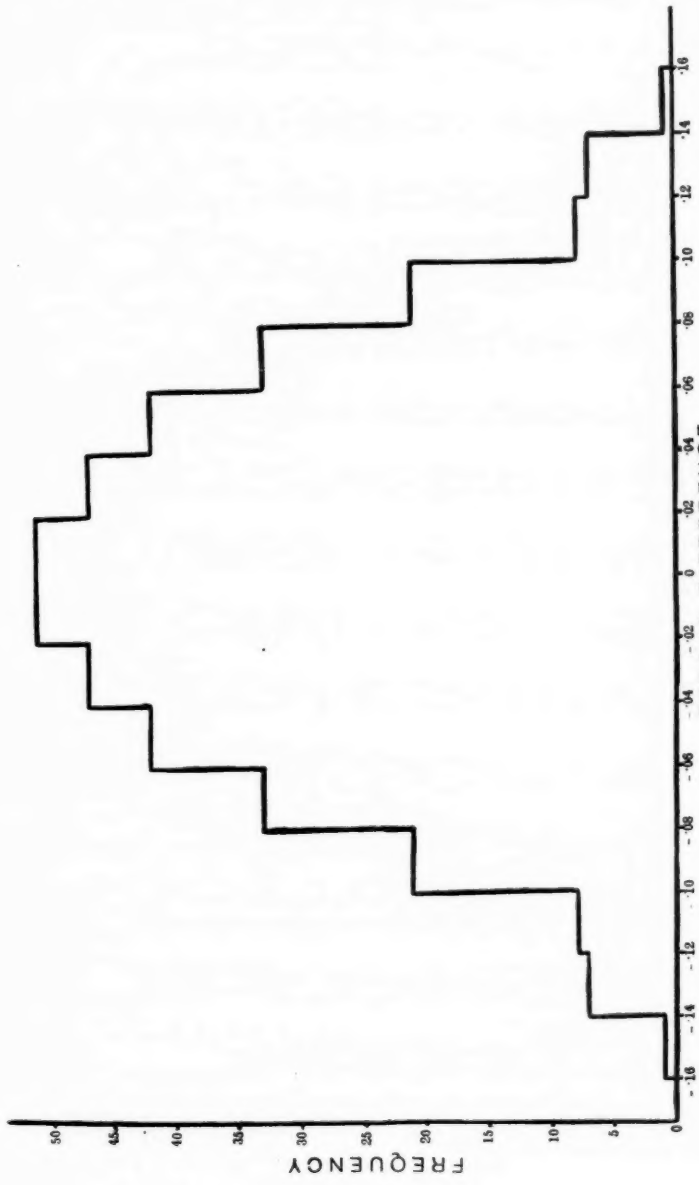
TABLE III.

	Tetrad Difference.								
	0– ·02.	·02– ·04.	·04– ·06.	·06. ·08–	·08– ·10.	·10– ·12.	·12– ·14.	·14– ·16.	Total T.D.s.
(*a*) Distribution of T.D.s ('F' tests only)	10	11	8	7	4	2	3	..	45
(*b*) Distribution of T.D.s ('F' tests and two reference tests)	51	47	42	33	21	8	7	1	210

For (*a*) Theoretical P.E.$_F$ = 0·032.
Observed P.E.$_F$ = 0·041.
Theoretical σ^2_F = 0·0022.
Observed variance = 0·0036.
For (*b*) Theoretical P.E.$_F$ = 0·032.
Observed P.E.$_F$ = 0·038.
Theoretical σ^2_F = 0·0023.
Observed variance = 0·0032.

purpose. Table III (*b*) and Graph II show the distribution of tetrad differences derived from the table of intercorrelations for all eight tests, obtained with my largest group of subjects. Again the observed and the theoretically expected dispersions show satisfactory agreement. Similar distributions were obtained from the other tables of intercorrelations, the observed median being, in one case, 0·039, as compared with the theoretical P.E. of 0·035 (N = 80), and in the other 0·032, as compared with the theoretical P.E. of 0·034 (N = 80).

I may add that when the influence of age on the correlation coefficients is eliminated, the distribution of the tetrad differences is not altered, thus confirming similar findings of Holzinger (10). Clearly, therefore, the general factor common to the 'F' tests is the same general factor as that



GRAPH II.—Distribution of Tetrad Differences, 'F' Tests and 2 Reference Tests, N = 104.

common to the "Measure" and the Arithmetic test—that is 'g.' Thus the 'F' tests are shown to measure only 'g' and specific factors—a result which corroborates the findings of Line (8), Stephenson (11), and Miss Davey (12) with other perceptual tests. Moreover, this holds regardless of the influence of age.

It was next incumbent to establish more exactly the value of each 'F' test as a test of 'g,' and, for the guidance of future research, the faults and virtues of each test and subtest, if possible. The results for each test were, therefore, subjected to a fairly detailed analysis. In considering these analyses, it must be borne in mind that results obtained with experimental tests such as these are liable to a great many errors, both statistical and others due to ambiguities and crudities in the material which only further experiment can help to abolish.

To begin with, all the tests differentiated a central school group of scholarship children from an elementary school group of children about the same average age who had failed in the scholarship examination, the difference in scores being statistically significant for all the tests except 'F' III.

I turn next to the tables of intercorrelations for my last group (Tables I and II), which, as I have mentioned, are representative of all the findings. All the raw correlations between the 'F' tests and the "Measure" are significant, being greater than 5 P.E. The reliabilities vary. For 'F' V and 'F' VI they are quite high, for the other tests they are medium to low. From the point of view of the ratio of validity coefficients to reliability coefficients, 'F' I and 'F' II and possibly 'F' III seem the most promising tests. The 'g' saturations of the tests seem to be about equal to that of the abbreviated version of the "Measure" which I used. Age correlates positively and significantly with Tests 'F' II and 'F' IV. 'F' II was also found to give a considerable negative correlation with age ($-\cdot25$) with a smaller and older elementary school group; but otherwise age seems to have little influence on success in the tests. The correlational results seem to indicate, therefore, that these perceptual tests—in particular Tests 'F' I and 'F' II—have a good deal of promise. This will be more evident perhaps from the following table (Table IV), where I have assembled the salient average coefficients for all the tests. Here the validity coefficients are all corrected for attenuation, and the reliabilities corrected by the Spearman-Brown formula. Some of the coefficients in this table deserve additional comment. First, the two contradictory correlations with age obtained for 'F' II. Closer analysis showed that these were almost entirely due to the first part of 'F' II, viz. 'F' II A. The negative correlation was obtained with a group of older children drawn from the highest standard in an elementary school. The younger children would, therefore, tend to be the

TABLE IV.

Salient Average Correlation Coefficients.

	'F' I.	'F' II.	'F' III.	'F' IV.	'F' V.	'F' VI.
*Average correlation . .	·71	·78	·50	·53	·63	·60
*Correlation with "Measure" .	·75	·79	·50	·47	·61	·61
Spearman-Brown reliability .	·70	·57	·56	·72	·79	·92
Correlation with age . .	·15	·29 −·25	·10	·19	·11 −·08	·04
Correlation with 'g' . .	·61	·66	·39	·47	·63	·69

(Coefficients marked * are corrected for attenuation.)

cleverer ones in this group, which explains the negative correlation with age. The positive correlation was obtained with a group drawn from several standards. In this case the younger ones would tend to be in the lower standards and would not always be the cleverer ones; hence the positive correlation with age. Defects in some of the subtests reduced the total score possible in 'F' II A and thus made it too easy for the clever groups, but it gave good correlations for the duller group; while, conversely, the more difficult parts of 'F' II, viz. 'F' II B and 'F' II C, gave better correlations for the cleverer groups. Test 'F' IV also gave a considerable positive correlation with age. This may be due to the fact that it was much too easy for all the subjects, showing differentiating power only with the dullest and youngest of them; or it may be that older children have in this test the advantage of greater acquaintance with patterns through drawing lessons in school. Test 'F' IV is, however, of undoubted utility with younger children, and has, in addition, this to commend it: that it can readily be extended almost without limit, since patterns are easy to discover or invent. Test 'F' VI is notable for its high reliability, but this seems entirely due to its great length—it generally took about 1½ hours to give. Though internal refinement of the subtests might raise its validity somewhat, it is open to question whether it could be so far improved as to be able to serve as a test of 'g' by itself.

To supplement the correlational analysis, I submitted the ' F ' tests to a further quantitative analysis along other lines. Each group of subjects was subdivided into smaller groups on the basis of their scores on the " Measure." The scores of these smaller groups on each subtest of each ' F ' test were then compared. In this way it was possible to determine (*a*) the relative difficulty of the subtests of each ' F ' test, and (*b*) the extent to which each subtest differentiated those who scored best in the " Measure " from those who scored worst—*i.e.* the diagnostic value of each subtest. Space does not permit a full discussion of these results, but some of the general conclusions may be stated.

(1) The diagnostic value of a subtest depends partly on the nature of the group tested.

(2) The best diagnostic subtests, on the whole, lie in a belt of medium difficulty between the second and third order of relational complexity—a result also arrived at by Hamid (13) in respect of verbal tests.

(3) Both diagnostic value and difficulty are dependent not only on the relational order of the subtest, but also on the amount of irrelevant elements, the degree of heterogeneity of the fundaments (especially in the case of numerical relations, such as ratios), and the " abstractness " of the relations.

(4) Tests ' F ' I and ' F ' II again revealed themselves to be the most promising. In particular, Test ' F ' II is recommended because of its tripartite form. This enables greater complexity in the eductive processes to be introduced and a wider range of difficulty to be covered than in single-form tests. Moreover, the three forms are sufficiently related to allow of the tasks being easily explained by reference to the form of ' F ' II A.

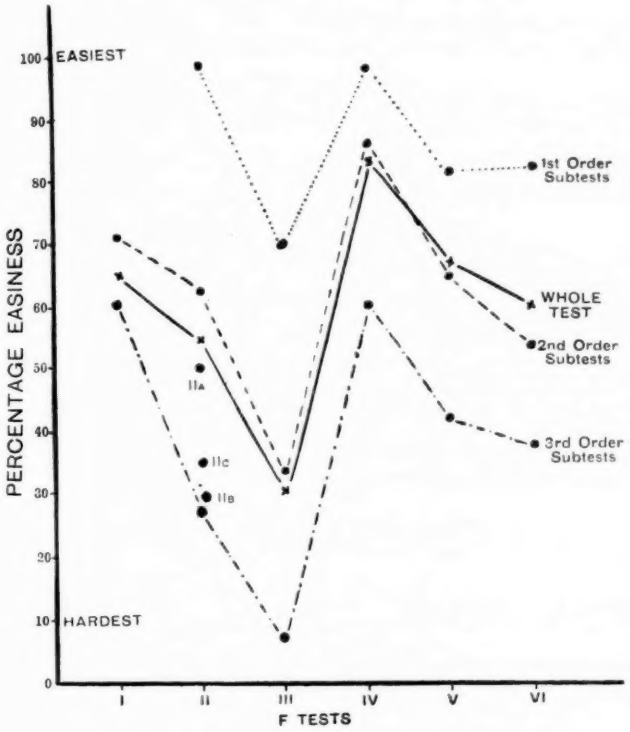
(5) The order of the critical relation cannot always be established *a priori*. Thus, in the case of the first subtest of ' F ' I, observation showed that for duller and younger children it would be more just to place it at the level of second-order difficulty, while for older and cleverer children it appeared to require no more than a first-order relation eduction.

(6) In every test there was a regular and parallel decrease in the score on each subtest, irrespective of its relational level, corresponding to the regular decrease in score on the " Measure." This is additional evidence of the multistratal nature of the growth of perception, which Professor Spearman has established and Dr. Line substantiated with considerable experimental evidence.

(7) The results on ' F ' VI provided a number of interesting observations. It appeared, for instance, that a subtest necessitating the simultaneous eduction of three first-order relations is not equivalent in difficulty or diagnostic value to one requiring the eduction of second-order relations. In so far as subtests of the former sort seem to tax mainly the " extensity," and subtests of the latter sort seem to tax mainly the " intensity " of

cognition, it is suggested that tests of this sort may be used to compare these two "dimensions" of cognition.

(8) The form in which a test is cast was seen to influence markedly the difficulty of the test at every relational level. The form of a test, that is, has a determinative effect upon the course of the cognition. Graph III



GRAPH III.—Relative Difficulty of the 'F' Tests, by Orders.

presents this finding. (*Note.*—100 per cent. is the "easiest" end.) This graph demonstrates too, that, on an average, the higher the relational order of a subtest, the more difficult is it, thus vindicating the basic method of increasing difficulty relied upon in this research.

The analysis of the tests was further pursued along two other lines. Firstly, a number of research students in this laboratory were kind enough to work through the tests with introspections. Interesting and informative as these introspective results are, it must suffice to state that they leave

no doubt as to the dependence of the tests upon relation and correlate eduction, and that they seem to suggest the presence of a conative factor in Test 'F' III. Secondly, a fairly elaborate analysis was made of the errors committed by the various groups of children tested. This throws a great deal of light upon the cognitive processes evoked by the tests, and should be of value in any endeavour to improve and refine them. The nature of my material largely excluded the possibility of reproductive errors. Those that did occur were generally due to the subject's interpreting a figure in terms of his past experience—for instance, as representing an animal or an object—and then educing a relation or correlate on the basis of this subsumption. Interpretation of the figures, therefore, far from being a *sine qua non* as in tests such as Dodd's, in the case of these tests leads to error. Displacement of eduction, due to indeterminate cognition, proved to be the most prominent source of errors. Thus, a judgment based on the general shape or outline of a figure, instead of upon the apprehension of the relations constituting the shape, was one of the displacement errors of frequent occurrence. I was also able to show statistically that though clever children are less prone to error than stupid children, they commit the same kinds of errors as stupid children.* This indicates that error is not a chance phenomenon, but is as much bound to the relational structure of the cognitive task as successful cognition is. It bears out too, that, qualitatively, the cognitive processes of children endowed with a large amount of 'g' are the very same as those of children meagrely gifted with 'g,' and thus justifies the distinction between qualitative and quantitative laws of cognition.

* The tables which yield this deduction are too elaborate to reproduce here, but an excerpt from one of them may serve as illustration.

Three erroneous choices were possible in each subtest of Test 'F' II A. In subtests 18 and 21 the percentage distribution of erroneous choices was as follows :—

Score on 'g' test.	Errors, subtest 18.			Errors, subtest 21.		
	a.	*b.*	*c.*	*a.*	*b.*	*c.*
Highest Group. .	52·6	10·5	36·8	7·1	85·7	7·1
Medium Group. .	68	13	19	15·5	77·8	6·6
Lowest Group. .	70·6	5·8	23·5	23·5	53	23·5

In both subtests the relative frequencies of the different errors are similar for all three 'g' groups.

In conclusion, while these tests are admittedly tentative, they seem to be of the greatest promise, both as tests of 'g' for inter-racial use and for further research in the psychology of cognition. One feels confident that further work along these lines should produce a highly dependable perceptual test of 'g' which will be universally applicable irrespective of race and culture.

Summary.

(1) Six perceptual tests of 'g,' involving only two-dimensional, "meaningless" figures, were constructed and applied to 240 school children.

(2) When the correlational results were tested by the Tetrad Criterion, the tests proved to be free of group factors—*i.e.* to measure only 'g' and specific factors.

(3) The relative difficulty and the diagnostic value of each test were determined and some of the factors upon which they depend elucidated.

(4) A study of the errors committed by the subjects was made, which substantiated the distinction between qualitative and quantitative laws of cognition.

BIBLIOGRAPHY.

(1) Binet and Simon.—"The Development of Intelligence in Children," Trans. Kite, Vineland, 1910.

(2) Healy and Fernald.—"Tests for Practical Mental Classification," Psychol. Mono., xiii, 1911, No. 54.

(3) Yoakum and Yerkes.—Army Mental Tests (Holt, 1920).

(4) S. C. Dodd.—"International Group Mental Tests," Ph.D. Thesis, Princeton, 1926.

(5) E. L. Thorndike and Others.—"The Measurement of Intelligence," Teachers' College, Columbia, 1927.

(6) C. Spearman.—The Abilities of Man (Macmillan, 1927).

(7) C. Spearman.—The Nature of "Intelligence" and the Principles of Cognition (Macmillan, 1923).

(8) W. Line.—"The Growth of Visual Perception in Children," Brit. Journ. Psychol. Mono. Suppl., 1930.

(9) L. M. Terman.—The Measurement of Intelligence.

(10) K. J. Holzinger.—Statistical Resumé of the Two Factor Theory (Chicago Univ. Press, 1930).

(11) W. Stephenson.—Ph.D. Thesis, Univ. London Library. Also his "Studies of Verbal and Non-verbal Tests," Journ. Educ. Psychol., xxii, 1931, 167–185, 255–267, 334–350.

(12) C. M. Davey.—Brit. Journ. Psychol., xvii, 1926.

(13) Hamid.—*Ibid.*, xvi, 1925.

Further information about the tests discussed in the present paper may be obtained from the writer.

THE GLACIATED SURFACES OF NOOITGEDACHT, NEAR KIMBERLEY, AND THE UPPER DWYKA BOULDER SHALES OF THE EASTERN PART OF GRIQUALAND WEST (CAPE PROVINCE), 1929.

By George Slater, D.Sc., D.I.C., A.R.C.S.,
Imperial College of Science and Technology, London.

With a Note on the Erratics by A. L. du Toit, D.Sc.

(Communicated by S. H. Haughton, D.Sc.)

(With Plates III–XII, and three Text-figures.)

I. Introduction—General Questions involved.

The recent visit to South Africa (1929) of the International Geological Congress and the British Association has undoubtedly stimulated interest amongst geologists in the evidence of past glaciations of that continent and in the Carboniferous glaciation in particular. Indeed, the unique striated rock surfaces of Nooitgedacht, near Kimberley, aroused such enthusiasm that a resolution was passed urging the enclosure of a part of this area as a National Reserve. The glacial origin of the Dwyka conglomerate, advocated by Sutherland in 1868, has been abundantly confirmed by later workers, as shown in a masterly review of the subject by du Toit in 1922 (8). The Dwyka deposits furnish evidence of a complete glacial cycle and of the isostatic movements which accompanied the glaciation and deglaciation of a continent and its adjacent seas. The maximum thickness of the Dwyka formation dwarfs that of the Pleistocene, whilst the outcrop on the geological map furnishes us with the most striking example of a glacial deposit of sufficient stratigraphical importance to rank equally with other members of the geological column. The character of the pre-glacial topography and the general conditions prevailing during the Carboniferous glaciation of South Africa have been summarised by du Toit in 1929 as follows :—

" The land surface was on the whole one of relatively small relief . . . a peneplain of small height from which rose certain blocks in the north-west, centre, and the north-east. . . . In the extreme west, in South-West

Africa, the moraine was deposited in a shallow ocean, while in the south the ice front seemingly passed into an extensive body of fresh or possibly brackish water, which followed up the ice front during its retreat, and in this the Upper Dwyka shales were laid down so far as the foot of the areas of higher ground referred to above " (13).

The ice front may perhaps have been closely comparable with the Antarctic Barrier.

Thus in Griqualand West the Dwyka Series consists of two facies of deposits, each of which is characteristic of a particular environment, the one formed by land ice, the other by deposition of glacial material in water. The area has fortunately escaped the earth movements which developed the cleavage in the tillite of the southern outcrop; Griqualand West is therefore particularly suitable for the study of the South African Carboniferous glaciation, especially from the point of view of physical geology. Moreover, the field evidence can be supplemented by the examination of microscope slides of the rocks.

When we recall the fact that the glacial origin of the Dwyka deposits was long in doubt and has even recently been contested, it is still more worthy of emphasis that the phenomena displayed should be so exceptionally characteristic of ice action. They not only provide classic ground for the South African student of physical geology, but in turn even throw light on puzzling problems of Pleistocene glaciation in Western Europe. In the latter region, the nature of the glacial deposits of the three great ice-collecting basins of the Irish, North, and Baltic Seas can only be inferred from sections around their peripheries, from the logs of coastal borings and from materials dredged from the sea bed. In South Africa we have in contiguity the area of erosional land ice at Nooitgedacht and Riverton, and that of glacial sedimentation, associated with floating ice, at the Harts and Riet Rivers.

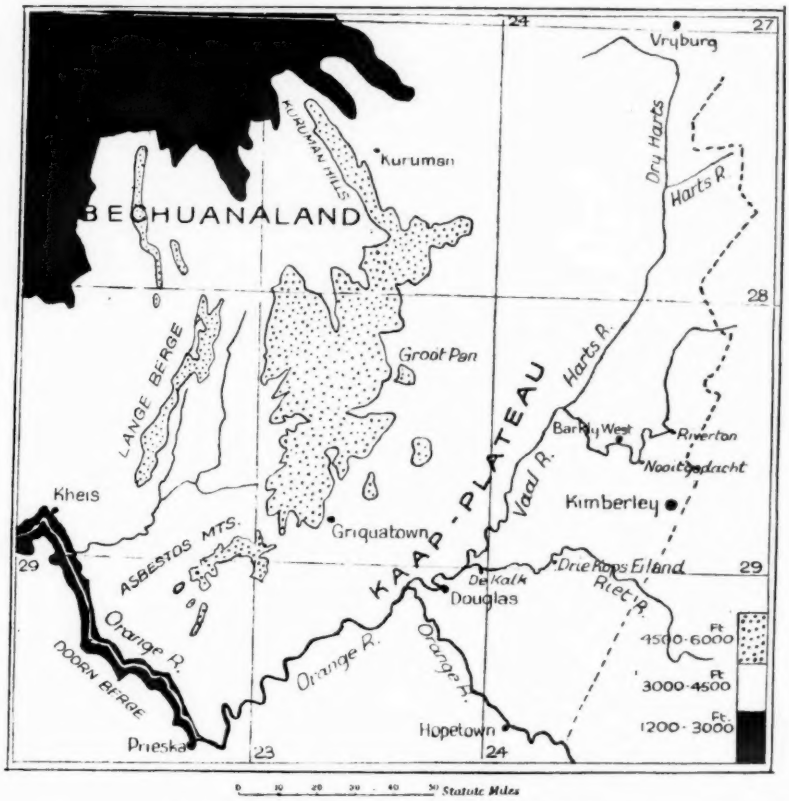
The following paper gives the results of a detailed examination of some type areas in Griqualand West, illustrating in a very clear manner the two facies of glacial deposits just mentioned.

II. Griqualand West—Topography.

As pointed out by du Toit in the paper cited (8), Griqualand West, which forms the north-western section of Cape Province, may be divided topographically and geologically into two well-defined areas. (Sketch Map, fig. 1.)

(a) *A Highland Block* some 150 miles from north to south, and about half that distance across, composed of ancient rocks belonging to the Transvaal System, the eastern scarp of which forms the

dolomite Kaap Plateau. During the initial stages of the ice accumulation this area formed an independent ice-centre, but during the maximum glaciation the local ice coalesced with two



SKETCH MAP OF GRIQUALAND WEST

FIG. 1.

other ice-streams, and the composite ice sheet was deflected southwards by the Highland Block.

(b) *The Longitudinal Trough of the Pre-glacial Kaap Valley.*—This trough lies to the east of the Highland Block (a), and runs parallel to the scarp in a north-east to south-west direction from Vryburg to Prieska, a line marked by the drainage area of the Harts-Vaal-

Orange Rivers. This trough marks the drainage system of the pre-glacial Kaap Valley, and guided south-westwards the Transvaal Ice Lobe, which produced the beautifully striated surfaces already mentioned. The concluding phase of deglaciation is characterised by the water-deposited facies of the Upper Dwyka boulder shales. These deposits filled the trough, now in process of being slowly excavated.

Kimberley, Douglas, and Prieska proved convenient centres for visiting some of the sections, whilst the study of other sections, which necessitated residence at the farms of Nooitgedacht and De Kalk, was rendered possible thanks to the assistance and hospitality of Mr. R. Ayliff Dold and Mr. M'Guffie respectively.

III. Nooitgedacht—Details of Sections. (Plate III, A.)

Nooitgedacht is the picturesque name of an extensive farm situated on the left bank of the River Vaal, about a dozen miles north-west of Kimberley (Map, fig. 1). The name is expressive of the refreshing change of scenery that suddenly meets the eye on approaching the valley from the monotonous and arid tableland, which occupies so much of the surrounding country.

The local scenery is enhanced by the existence of a subsidiary valley or small amphitheatre, about a mile in length, which occupies a small area of the farm. This valley exposes the glaciated outcrops of the Pneil Diabasic Lava Series, visible on the sides of the valley and also in the central part, where they have been eroded into an isolated kopje, together with numerous bosses. These topographical features furnish instructive examples of " crag-and-tail " phenomena (Map, fig. 2).

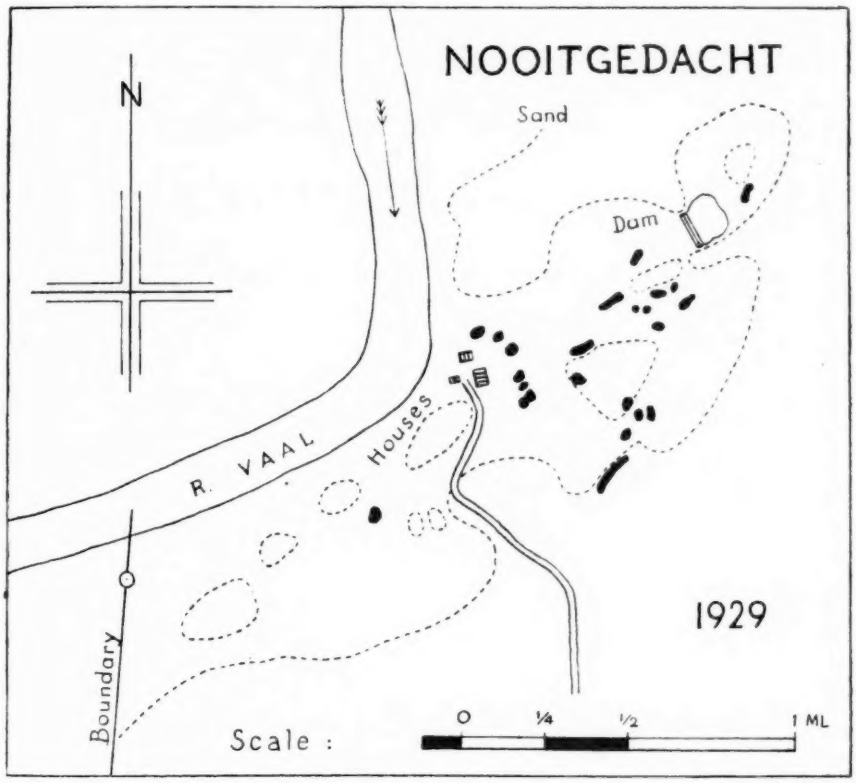
In the floor, and to some distance up the sides of the valley, the country rock also occurs as a series of striated rock surfaces associated with overlying deposits of boulders, tillite, and varve shales.

In a country like South Africa, devoid of recent glaciers, the evidence of this fossil glacial landscape is of the utmost educational value. All the typical examples of glacial phenomena occur within half a mile of the farm buildings, and it is satisfactory to learn that this unique area, which rivals in interest the Glacial Garden of Lucerne in Switzerland, will be protected thanks to the public spirit of the De Beers Corporation.

The general direction of the movement of the ice was from the north-east, that is, down the valley; hence there is a remarkable change in the appearance of the landscape when viewed alternately from the south-west and the north-east. When the observer stands near the farm buildings and looks up the valley, the leeward flanks of the igneous rocks produce a

rugged aspect, whereas, if he looks down the valley towards the farm buildings, the glistening striated rock surfaces of the iceward flanks present a striking spectacle.

The striated surfaces are best developed on the south-western side of the valley, adjacent to the farm buildings (fig. 2). A longitudinal section



B. Aylff Dold.

Fig. 2.—The glaciated surfaces of Nooitgedacht.

brings out the fact that the valley partakes of the nature of a rock basin, which was ultimately converted into a glacial lake or arm of the sea, as shown by the varve shales. A traverse of the south-western side of the valley proves that the rock has been eroded into an uneven floor, the striated surfaces of which consist of portions of dome-like forms, separated from each other by longitudinal hollows filled with tillite. The rock surfaces adjacent

to the farmhouse display instructive examples of glacial abrasion and polishing.

Nature of the Striated Rock Surfaces.—" The volcanic group consists very largely of blue or green diabasic lavas (originally basaltic andesites) weathering with a thin dark red coat ; they are in places highly amygdaloidal, with the vesicles filled in with quartz, calcite, or chalcedony " (10, p. 75).

Of especial interest is the weathered dark red crust of the striated rocks at Nooitgedacht and other areas, the petrology of which is described in the following report by Dr. A. Brammall.

" The mineral constituents (felspars and chlorite, probably after aluminous pyroxenes) immediately below the striated surface show neither pressure nor shear effects : the texture and microstructure are uniform from end to end of the section. Within a superficial zone 2 mm. thick, oxidation of the chlorite (with production of stains and clots of limonite) is emphatic. The same kind and degree of alteration is shown along a feeble fracture or joint plane to a depth of 7 mm. Between the two zones of oxidised (limonitised) chlorite, yellowish green chlorite prevails—with essentially no limonite. This medial zone may be safely regarded as representing the degree of pre-glaciation alteration. Both the striated surface and the joint plane are filmed with limonite, reddish enough to indicate its partial dehydration to hæmatite—as in laterite."

The process of weathering has therefore been in the nature of replacement, and this replacement of the chlorite, etc., has not destroyed the striations on the glaciated surface. The process is analogous to the replacement as a pseudomorph of a crystal of pyrite by limonite.

As remarked in the introduction above, the details of the records of glacial action at Nooitgedacht are more than usually instructive to the geological student. No apology therefore is needed for the following descriptions of specific phenomena. The beautiful photographs by Mr. A. M. Duggan Cronin which accompany this paper illustrate most of these features in a remarkably clear manner ; for permission to use these the author is deeply grateful.

A. Glacial Abrasion and Polishing.

(a) *Striated Rock Surfaces.* (*Cf.* Plate III, B and Plate VI, C.)

The striated rock surfaces occur as inclined surfaces on the iceward limbs of bosses of rock which formed obstructions to movement of the ice. As with modern glaciers, it is noticeable that the double set of joints in the Pneil Volcanic rocks is unaffected by glacial action on the iceward limb,

in marked contrast to the pluck phenomena characteristic of the leeward limbs of the obstructions.

(b) *Relief Polishing.* (Plate IV, B.)

Excellent examples of relief abrasion occur, proving that ice acts as a soft abrasive. The differential hardness of the minerals of the amygdaloidal lavas has been taken advantage of by the ice. Infilled "gas blow-holes" stand up as prominences, amygdaloids filled with chalcedony form minor elevations, whilst those containing calcite are hollowed out, giving a pitted surface to the rock.

(c) *Chatter Grooves.* (Plate IV, A.)

Chatter grooves frequently occur, and occasionally the boulder responsible still lies at the end of its unfinished groove. Thus it is proved that abrasion of the rock by ice was a continuous process up to the final stage of deglaciation, when the tillite was deposited.

(d) *Crag and Tail.*

At a point situated a few hundred yards south-east of the house is a good example of the crag-and-tail phenomena associated with the stream-line form developed by ice flowage.

The "crag" (Pl. III, B) is the finest example in the district; its apex is marked by a small transverse selvage along a joint plane, which marks the abrupt cessation of abrasion by polishing, and the commencement of pluck on the leeward limb. Joints now become of paramount importance in aiding disintegration of the rock by ice. The tail of débris, composed of tillite with many boulders, is well developed; here also lateral compression of the tillite produces a longitudinal median ridge.

A longitudinal section up the slope of the hill brings out the fact that the minor topographical features all represent repetitions of the crag-and-tail phenomena at successively higher levels, each individual feature showing in plan the stream-line form of the crag-and-tail phenomena (fig. 3, *f*).

(e) *Glacial Grooves.*

Glacial grooves are a common feature of the Nooitgedacht area, excellent examples being shown in Pl. V, B and C. The trend of the grooves usually coincides with that of the main direction of the striations, one side of the groove being steeper than the other.

A variant of this type may be seen associated with a rounded boss of

rock adjacent to (d) above. In this exposure two shelves occur *en échelon* adjacent to the dome-like glaciated rock, the trend being generally in the direction of one of the sets of joint planes. These shelves contain remnants of tillite (Pl. V, A).

(f) *Roches-Moutonnées.* (Plate VI, A and B, and fig. 3, profiles *c* and *e*.)

In the central part of the Nooitgedacht area, half a mile north-east of the farm, two *roches-moutonnées* may be seen associated with crag-and-tail phenomena. One of these exposures contains erratics on the iceward limb, some of them still resting in their chatter grooves.

Longitudinal sections of these *roches-moutonnées* illustrate the graceful and characteristic drumloid curve, and suggest that the crag-and-tail phenomenon represents the structure of a drumlin which has a rock nucleus, termed by Fairchild a " rock-drumlin."

Pluck phenomena are well seen in the flank of one of these *roches-moutonnées*, and the commencement again coincides with that of a transverse line drawn through the apex.

The profiles of the *roches-moutonnées* (fig. 3) illustrate the principle that a definite relationship exists between the height and the relative areas of the iceward and leeward flanks. Progressive decrease in elevation results in a greater extension of the iceward flank or zone of abrasion, whilst the higher the elevation the greater the amount of pluck. The summit of an isolated elevation suffers more glacial erosion than the lower ground beside it, because of an abnormally high velocity gradient at this point. Moreover, the progressive decrease in elevation of an obstruction gradually diminishes external and internal friction, and both sliding and flow of ice is facilitated, resulting in the formation of low hummocks over which the ice passes with comparatively little effect (6). Hence the earlier stages of glacial erosion are mainly due to pluck, the latter stages to abrasion. The sharp line of demarcation between the two zones is interesting geologically as supporting the view expressed by physicists that ice rapidly conforms to physical changes which affect its movement.

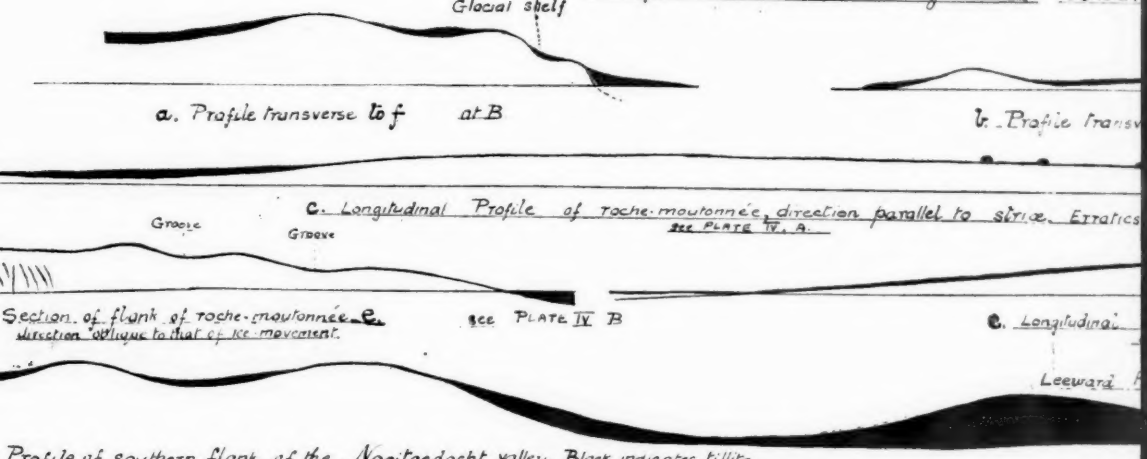
B. The Tillite.

Compared with the abnormal development of the tillite in the southern outcrop, the thickness of this deposit at Nooitgedacht is negligible, and although it varies much in thickness in various parts of Griqualand West, its distribution agrees with the general law that glacial deposition is dominant in the periphery of the ice-collecting area. In the floor of the Nooitgedacht valley the tillite rests on the glaciated country rock and is

d. Section of fl
direction obliq

f. Longitudinal Profile of s

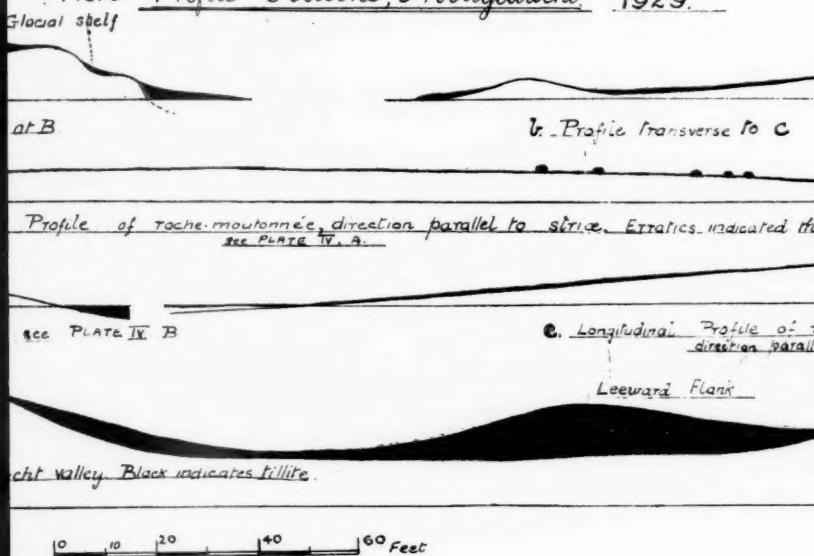
FIG. 3 Profile Sections, Nooitgedacht 1929.

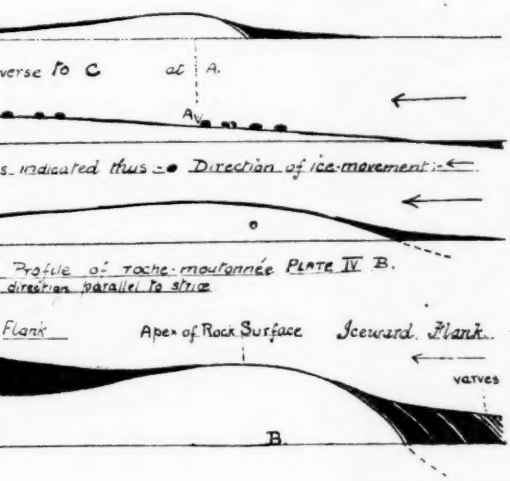

Glacial shelf
a. Profile transverse to f at B
b. Profile transv
c. Longitudinal Profile of roche-moutonnée, direction parallel to strike. Erratics
see PLATE IV. A
Groove
Groove
Section of flank of roche-moutonnée e. direction oblique to that of ice-movement.
see PLATE IV B
e. Longitudinal
Leeward

Profile of southern flank of the Nooitgedacht valley. Black indicates tillite

0 10 20 40 60 Feet
Scale - Vertical & Horizontal

FIG. 3 Profile Sections, Nooitgedacht 1929


Glacial shelf
at B
b. Profile transverse to C
Profile of roche-moutonnée, direction parallel to striæ. Erratics indicated th
see PLATE IV. A.
see PLATE IV B
c. Longitudinal Profile of
direction parall
Leeward Flank
cht valley. Black indicates tillite.
0 10 20 40 60 Feet
Scale - Vertical & Horizontal



To face page 308.

overlain by the varve shales. It fills the hollows, and is associated with the crag-and-tail phenomena.

An extremely interesting structural feature of the tillite is the presence of a glacial tillite pavement adjacent to the farmhouse. The upper surface of a thin deposit of tillite is grooved and fluted, and is similar, though on a smaller scale, to the much finer examples at Riverton and Eland's Vlei (2 and 5).

The petrology of the tillite is of interest. Apart from the finer material, some of which may be regarded as local rock flour, the constituents are extra-local in character, a fact which supports the view expressed by Tiddeman in 1872 that the local effect of the country rock in the production and coloration of boulder clay may not be immediately apparent, but is increasingly so farther afield in the direction of ice movement (1).

Rock slides were prepared (Pl. X, A and B) from the Nooitgedacht tillite, and were kindly examined for me by my colleague, Dr. A. Brammall. His report on the petrology brings out the points that the angularity of the fragments and the weathering of their crusts are characteristic features. Chert, quartz, felspars, phyllite, tuffs, and intermediate to basic lavas are present. The fragments, of varying sizes, are embedded in a dark brown highly ferruginous and almost opaque paste (recalling laterite). Two fragments (out of say 100) may have been derived from diabasic rocks of the Riverton type, but it is doubtful whether the Nooitgedacht type is represented at all among them. The physical character and ferruginous content of the matrix are certainly consistent with incorporation of "local" rock flour, but it is not possible to decide in what proportion such local material is present in the matrix.

C. The Nooitgedacht Erratics and their Bearing on the Course of the Dwyka Ice Body. (By Alex. L. du Toit.)

Although the inclusions are of varied kinds, the majority of them are of no value in this connection—for instance, the granites, gneisses, pegmatites, grey dolomite and associated chert, or the various sorts of quartzites, that are of widely spread and not sufficiently distinctive types.

As could be expected, in view of the huge area stretching to the north-east that is composed of Ventersdorp volcanics, the bulk of the erratics consist of such blue-green diabases, ranging from medium to fine-grained and occasionally porphyritic stony lavas to highly vesicular kinds with the cavities filled with chlorite, quartz, or chalcedony, which last is sometimes vermilion in colour. Some paler and more acid lavas are also represented.

Interest centres in the quartz-porphyries that form such a conspicuous component of the tillite in this region; one such erratic, split into two,

measures 6½ feet by 4 by 3. They have a grey, greenish, bluish, or pinkish stony base in which are set grey, salmon, or red porphyritic crystals of orthoclase and blebs of dark glassy quartz, with subordinate biotite and chlorite. Varieties with vesicles and druses are less frequent. Quartz-porphyry breccias and tuffs are also present. Identical types crop out extensively some miles to the south-west, south and south-east of Wolmaranstad in the Transvaal, where they build the but-little-known Maquassi Hills. Inclusions of these rocks have been found by the writer in the Dwyka tillite near Kingswood Station, only a few miles to the south-west of this area of acid rocks, and also on Zoutpan nearer Bloemhof, and it can hardly be doubted that the quartz-porphyry inclusions, so noticeable along the Vaal River region, have their source in the complex situated near to Wolmaranstad.

A fair proportion of the erratics consists of grits and conglomerates characterised by an abundance of detrital felspar; indeed, some can be described as arkoses. They carry inclusions, angular, subangular, or well-rounded, of dark vein quartz, quartzite, granite, gneiss, pegmatite, banded cherty slate, and quartz-porphyry. These types can be matched among the coarse strata belonging to the basal part of the Ventersdorp system, described by Hatch under the name of the "Boulder Beds of Ventersdorp," that crop out in a belt to the west and east of the town of that name.

Certain dark quartzites and grits are rather like those of the Lower Witwatersrand that are exposed in the Wolmaranstad and Klerksdorp districts. Others may be compared with those of the Pretoria Series.

Of significance is a block, a foot across, of hard black slate with glittering crystals of andalusite. It has most probably been derived from the zone of hornfelsed Pretoria slates that stretches between Koster and Zeerust.

Some inclusions of what seems to be the Bushveld Diabase were noted, but no undoubted ones of the Bushveld Norite were seen, though such types could easily be overlooked. In the Barkly West district erratics of the red Bushveld Granite have been recorded. A pebble of deep red, fine-grained quartzite strongly resembles certain of the Rooiberg rocks represented to the west of Warmbaths, a resemblance furthered by the occurrence of red quartz felsites more like those of the Rooiberg than those of the Ventersdorp system.

The evidence from Nooitgedacht is in full support of the conclusion arrived at from the study of the striated surfaces, namely, that the contents of the tillite were derived from the territory situated to the north-east of that spot. The writer has found in the tillite on Zoutpan, north-east of Bloemhof, lumps of red Rooiberg quartzite and felsite, and at Roodepan, east of Lichtenburg, of red Rooiberg felsite and granophyre, red granite

and red Waterberg grit. These transported blocks tend to support the view that some of the ice that overrode the Nooitgedacht area originated so far to the north-east as the northern side of the Transvaal Bushveld, a distance of at least 300 miles.

D. The Nooitgedacht Varve Shales. (Plate VII.)

The floor of the subsidiary valley contains a deposit of varve shales known to be 15 feet in thickness and to overlie a remnant of the tillite. The best section occurs in the central part of the area (Map, fig. 2), and is shown in Pl. VII, D. It may be noted in this illustration that whereas the beds in the foreground are horizontal, those in the background, adjacent to a glaciated rock, dip 40° N., a fact which may be due to some extent to deposition on an uneven floor. In view, however, of the evidence of another section 300 yards east of the farmhouse, which shows disturbed varve shales a foot in thickness, associated with an embedded small boulder and intercalated in the tillite (Pl. VII, C), the evidence suggests a local recession and re-advance of the ice, a movement which may be correlated with the formation of the tillite pavement near the farmhouse. In spite of the beautifully bedded nature of these shales (Pl. VII, A), it is doubtful whether we are justified in applying the term " varve " to them. A typical varve consists of alternating layers of two types of material deposited in water.

(*a*) A very fine-grained layer, often dark coloured composed of graded material, deposited in winter beneath ice. The lime content is usually poor.

(*b*) A relatively coarse, often light coloured but graded layer, deposited in summer. Where lime-bearing rocks occur, it is frequently rich in micro-granular calcite, the precipitation of the finely divided calcium carbonate being due primarily to increase of temperature which reduces the solubility of carbon-dioxide. This layer grades upwards into the fine-grained deposit.

It cannot be said that these requirements are fulfilled to any marked degree in the Nooitgedacht varves. The microscope section shown in Pl. VII, B, hardly shows the standard of grading of a typical Pleistocene varve. Calcareous bands were not revealed by hydrochloric acid in the specimens examined. Indeed the South African evidence supports the view that the presence or absence of calcareous bands in these varves is determined by the composition of the country rock from which the material was derived, for at Douglas calcareous bands in the varves are extremely well developed and are associated with cone-in-cone structure, a fact which may be connected with derivation from ice which passed over the dolomitic plateau.

In view of the absence of varve grading, it would be better to use the term " varve-like " in reference to these deposits (13).

IV. The Glaciated Pavement of Riverton.

(Map, fig. 1, and Plate VIII.)

The Riverton glaciated pavement is situated on the banks of the River Vaal about 16 miles north-north-east of Kimberley. It was most conveniently reached by motoring to the " Pumping-Station," and from thence, thanks to the courtesy of the Mayor of Kimberley, by motor-launch up the river to " The Hook " (Khosop's Kraal) in the Harrisdale district, a distance of three miles. This stretch of the river contains well-known examples of *roches-moutonnées*, although one, forming an island in the river, is now partially submerged as a result of the construction of a dam (3).

The Riverton glacial pavement lies on the iceward limb of a glaciated hummock of diabase which has protected the glacial conglomerate on its south-western side from complete removal and has been instrumental in the formation of the pavement.

Composition of the Pavement.

At the base of the hummock, adjacent to the river, is an isolated exposure of silt-like material 8 feet in length and 1 foot in thickness, containing a prominent embedded erratic, this deposit resting on the country rock. Nearer the crest on the south-eastern side is a stratified calcareous sandstone 5 inches in thickness, with the bedding planes etched out. A microscope section suggests that this is a water-deposited rock.

The glaciated pavement proper is composed of three types of rock. On the south-eastern flank, nearer the crest, is found :—

(1) A hard, slabby, ferruginous siltstone composed of angular particles of quartz incorporated in glacial mud. The upper surface is beautifully moulded into a series of parallel shallow grooves, which are repeated in the underlying layers.

(2) Pale grey varves intercalated with silt particles of quartz which show a tendency to parallel orientation. This bed is moulded into deeper grooves, resembling picture-frame moulding both in form and smoothness (Pl. VIII, A). A microscopic and megascopic examination clearly indicated vertical pressure, suggesting that the material, when moulded, was unfrozen, thus allowing freedom of movement of the particles (Pl. VIII, B and C). This evidence supports the view expressed by the late J. W. Evans, discussing the physics of glacier ice (6, p. 284), that " the lower

surface of the ice is usually at the melting-point corresponding to the pressure to which the ice is subjected, so that the interstices of the rock below are filled with water at its freezing-point."

(3) The main part of the pavement, however, occurs on the south-western flank and is composed of tillite, about 3 feet in thickness. This exposure has been lucidly described in an official report (1906) as follows :—" At the northernmost outcrop there are long furrows in the glacial material, a few feet wide and up to two feet in depth ; they are exposed over a length of 250 feet, and have a constant inclination, rising gradually to the south-west. The material seems to have been gouged out by the ice sheet ; large boulders embedded in this ' glacial pavement ' show striations parallel to the direction of the furrows and ridges. . . . The striations continue evenly from the furrows on to the crown of the diabase hummock, and cross the older and more westerly directed striae. The furrows are in some places filled in with more boulder material, in others they are overlain by greenish shales " (4, pp. 112–13).

The upper surface of the glaciated pavement clearly suggests the presence of a thrust-plane seen in plan, whilst the depth of the grooves and the plastic moulding of the material indicates lubrication of the sole of the thrust.

An interesting feature of the pavement is the relationship suggested between the depth of the grooves and the lithology of the floor. The parallel flutings on the surface of the sandstone, for example, are only a few millimetres in depth. The varve-like material has a wave-like surface, the amplitude of the waves varying up to a maximum of about an inch, whereas the grooves in the tillite are up to 2 feet in depth. This variation in depth may be correlated with the varying degrees of plasticity of the respective rocks when lubricated during the formation of the pavement. There is a median ridge of tillite, 3 feet above the level of the glaciated country rock, which contains a much wider hollow, but this has probably been accentuated by subsequent erosion. The small depth of the grooves in the varve-like material may be the result of its being only a veneer on more rigid country rock. The evidence of the striated pavements supports the hypothesis that they mark a recession and re-advance of the ice sheet (10, p. 211).

V. Laboratory Experiments in producing Attrition, Abrasion, and Polishing of Rocks.

As stated above, the Riverton glacial pavement yields evidence that the sole of a glacial thrust-plane on the iceward limb of an obstruction to

movement is lubricated. This fact is of considerable interest from the point of view of the mechanics of glacial erosion. Inasmuch as, under such conditions, the cohesion of the underlying surface of the country rock is not increased by freezing, it follows that the dominant factors in the amount of material removed by glacial abrasion are the petrology, the relative hardness, and the nature of the cement of the country rock. This conclusion justifies comparison between the results produced by the ice and those attained experimentally in geological and metallurgical laboratories. Some idea of the probable amount of differential erosion of rock outcrops may be obtained from the results of attrition tests in the laboratory.

(a) *Attrition.*—Tests on road materials have long been made, notably in England and America. As an example, the results obtained by the use of the Lovegrove machine may be cited (12).

Diabase.—The average loss of 123 rocks is 12·37 per cent., showing that in this type the wearing power takes a middle position between the highest and the lowest figures.

The average *dry* loss of this series is 8·23 per cent., that of the *wet* loss being 16·51 per cent. This remarkable difference is probably due to the abundance of fibrous and platy secondary minerals, such as serpentine and chlorite, which are easily disintegrated by the penetrating action of water.

As quartzites and dolomites form part of the country rock in other parts of Griqualand West, the results obtained from similar rocks will be given by way of comparison.

Quartzites.—Of the thirteen quartzites tested, the average loss is 5·99 per cent., which is the lowest of any petrographical group. Attrition depends principally on the strength and induration of the cementing material.

Limestones and Dolomites.—Owing to the perfect cleavage of calcite this series reached the high average attrition loss of 18·92 per cent.

It is evident, therefore, that the dolomitic Kaap Plateau would suffer from glacial erosion to a greater extent than other areas in the district. The effect of this erosion is seen in the prevalence of calcareous material associated with the Upper Dwyka boulder shales of the preglacial Kaap Valley.

(b) *Abrasion and Polishing.*—In laboratory practice the nature of the surface used for polishing has a considerable effect on the polished surface. For obtaining perfect smoothness, a hard support, such as glass, is necessary whereas should *relief polishing* be desired, a soft ground, such as cloth or leather, is required. Such a ground causes the softer constituents to be worn rapidly, leaving the harder constituents in relief. It was noted under (b) in

Section III that relief abrasion occurred on the Nooitgedacht pavement. The ice must therefore have acted as a soft abrasive, like the cloth or leather mentioned above. This is to be attributed to the granular structure and regelation of the ice at its contact with the rock.

In order to reproduce as far as possible the degree of smoothness of the glaciated surfaces, specimens of glacially striated rocks were selected for treatment in the rock-cutting laboratory. These included a diabase from Nooitgedacht, a quartzite from Jackal's Water, Prieska, and a limestone.

Using 90 carborundum abrasive and then 3F carborundum a surface was produced on the diabase, in a few minutes, somewhat smoother than the glaciated surface. Further polishing with Water of Ayr stone and abradum on the " buff-wheel " produced a polish much better than that by the ice.

Now the investigations of the late Sir George Beilby (7) prove that the prolonged polishing of a crystal of antimony or of calcite with rouge and a wash-leather ultimately produced a film over the striated surface which could be removed by etching. Comparison between the glaciated surfaces and the portions of the specimens polished in the laboratory shows that in these examples the degree of smoothness attained by the ice only reaches the preliminary stage of final polishing. This may be accounted for by the fact that the abrasive used by the ice is of *mixed grades*, and hence it is impossible for the ice to form the highest degree or the "*film stage*" of polish, as in metallurgical practice, for the coarser ingredients in the ice will always produce deeper grooves.

In concluding this section of the paper it may be pointed out that the inferences drawn from the evidence already described as to the physics of ice when meeting obstructions to movement are in accordance with the results obtained by physicists from experimental study. R. M. Deeley, for example, describes the behaviour of ice under such conditions as follows :—

" When the glacier moves down a valley it presses heavily against each boss or hummock it touches. Here melting takes place and the temperature is low, but if the rock be dense and impervious the water cannot readily escape. However, on the top and lee side of the boss the pressure is relieved, the water escapes through grooves, joints, etc., and the ice freezes to the rocks with which it is in contact, tearing up, if the joints allow it to do so, large masses which are then carried forwards. . . . In this way the whole forward stress of large masses of ice is concentrated *locally*, and the hard floor is dealt with in detail." *

* 1879, Geol. Mag., Decade iv, vol. iv, pp. 388–397, " The Erosive Power of Rivers and Glaciers."

VI. The Upper Dwyka Boulder Shales.

In contrast to the phenomena described under Sections III and IV above, the features of which are so characteristic of the work of land ice, we turn to the evidence of the Upper Dwyka boulder shales of the De Kalk area, which it will be demonstrated are characteristic of water deposition of glacial material.

The best exposures of the Upper Dwyka boulder shales in Griqualand West occur in the neighbourhood of the river systems, natural sections in the surrounding tableland being rare. Details of these deposits have been published in the various reports of the Geological Commission of the Cape of Good Hope, and a general summary of the salient features of this formation in South Africa by du Toit (10).

In the areas of Griqualand West, where these shales are best developed, there is a distinct type of glacial deposits in the Harts-Vaal River Valley, and for a short distance up the Orange and Riet Rivers. This type consists of alternations of boulder shales, gravel Dwyka, bedded Dwyka, shales, and limestones, followed by black shales in which boulders are frequently present (4, pp. 115–116). The boulder shale consists of a fine-grained bluish or blackish green shaly material in which are set rounded and well-striated boulders of various rocks of all sizes, with no definite arrangement or orientation.

An extremely interesting feature of the Upper Dwyka boulder shales is the presence, notably in the lower part of the shales, of hard bands of what the author describes as "tillite-like material." The presence of these bands has long been known, and was noted in 1906 as follows :–

"Attention has been directed by Messrs. Young and Johnson to certain bands which are enclosed by the boulder shale and lie at all angles. Owing to their superior hardness they project above the surface of shale and form ribs and dyke-like masses. The material of which they are composed varies from a sandstone to a conglomerate. Sometimes the shales in which they occur are contorted, indicating the effect of pressure, but in most cases these gritty bands have been deposited in their present positions" (4, p. 116).

The base of the shales is not exposed at De Kalk, but is to be seen at Drie Kops Eiland (Kaffirs' Dam) on the Riet River. Here the margin of an extensive area of glaciated rock is overlain by about 10 feet of tillite slightly contorted in places, with an uneven surface upon which the boulder shales were deposited. A thickness of 15 feet of the shales contains five hard bands, having a very slight dip. A little farther along the left bank shales overlain by a hard band are exposed between two glaciated bosses

of rock for a distance of 700 feet. These deposits show an increase of dip adjacent to the rock (Pl. IX, C), but elsewhere are nearly horizontal.

The shales are well developed in the basin of the Orange River, north of Prieska, which forms part of the longitudinal trough of the pre-glacial Kaap Valley. The two facies of glacial deposits of this area each show definite structural characteristics, the land-formed tillite at Fontein Farm showing evidence of drumlin structure in a series of superimposed thrust-planes, while the water-deposited shales with their intercalated bands are well exposed in an adjacent valley near Hospital Farm. Here, in a section extending for a length of 400 yards, two well-defined calcareous bands are seen in a thickness of from 20 to 40 feet of shales with a gentle dip.

For the purpose of comparing the calcareous bands with the tillite, microscope slides were prepared and kindly reported on by Dr. A. Brammall. Without going into unnecessary detail, it may be said that the Fontein Farm (Prieska) tillite and the Hospital Farm calcareous band differ in no essential petrological feature. In both cases the outstanding character is the marked heterogeneity of the angular constituents and the preponderance of equigranular calcite (Pl. X, D).

The type section of the Upper Dwyka boulder shales occurs at De Kalk on the southern bank of the Riet River, four miles above its junction with the Vaal. This section can be reached by train to Broadwaters Station near Douglas, and from thence by car to the farm of De Kalk. The exposure reaches 100 feet in height and extends north-south for a mile and a quarter on the left bank of the Riet River, forming in places an almost vertical cliff. The section was plotted to a scale of 1/1200 (Pl. XII). It has previously been described in an official report (4, pp. 115–117) and illustrated by a sketch.

The succession adopted by the official survey is grouped in the author's section, Pl. XII, as indicated in the following table :—

	1909.	1929.
9.	Calcareous tufa capped by gravel	4
8.	Black shales with thin limestones and occasional boulders.	
7.	Limestone	2
6.	Boulder shale.	
5.	Black shales with a few boulders.	
4.	Limestone (6–18 inches)	H.B.
3.	Black shales.	
2.	Boulder shale and gritty conglomerate . . .	1
1.	Shales with dyke-like masses of grit and conglomerate. Dark fine-grained sandstones and flagstones are developed in the northern part of the section . .	3

A. The Dyke-like Masses of Grit and Conglomerate.

(Plate XII, Bed 1, and Plate IX, A.)

The expression " dyke-like masses " for the harder bands in the shales is only apposite where disturbance and weathering has resulted in their assuming such a form. The author's term " tillite-like material " covers these dyke-like masses and also the calcareous bands already mentioned, in their undisturbed condition.

Special attention was given to the dyke-like masses of grit and conglomerate near the base of the section forming Bed 1 of Pl. XII. They occur as slabs with smooth faces, and vary from a few inches to about a foot in thickness. The texture ranges from that of a finely grained calcareous deposit to a coarse bouldery conglomerate.

The microscopic examination of these rocks is interesting from two aspects, namely, the petrological composition, and the arrangement of the contents relative to one another.

(a) *The Constituents.*

Dr. Brammall's reports on the petrology of three specimens bring out the following points :—

(*a*) They are all markedly calcareous.
(*b*) They are extremely hard and quite unweathered.
(*c*) The hardness is explained by the character of the constituents, which include quartz, chert or devitrified volcanic rock, felspars and igneous rocks of the type of diabase, microsyenodiorite, aplite, and andesite.
(*d*) They contain curious pellets of fine-grained material described below.

(b) *Relative Internal Arrangement of the Constituents.*

(Plate XI, B.)

The microscope slides of the calcareous bands of De Kalk revealed the extremely interesting development of different stages of layering of the constituents, this feature ranging from an example where it was hardly perceptible to others where it was associated with oval-shaped pellets. As the bands are absolutely fresh and unweathered, the layering must be connected with their original deposition.

The mechanical composition was as follows :—

Largest fragment = 1·2 mm.		Combining these two. Perhaps 10 per cent. of the grains.
Next grade-size = 1 mm. to about 0·4 mm.		
Remainder = Varying around a mean of say 0·1 mm.	90 per cent. ?	

Probably the most interesting feature displayed by the slides is the presence of faint layering associated with oval-shaped pellets of fine-grained material. The material of the pellets is probably a " facies " of the same type of rock as that of the bulk of the tillite, and indicates variants due merely to higher (or lower) proportions of fragments. In Pl. XI, D there is also a faint suggestion of " layering " throughout, and one zone can, with some confidence, be referred to as a layer, wherein sorting of a rough kind has occurred. The pellets are well developed in another specimen shown in Pl. XI, C.

The three specimens described all effervesced freely with hydrochloric acid, as would be expected from their microscopic character. The content of calcium carbonate is very suggestive in view of the presence of flecks and pellets of fine-grained material, for it is almost impossible to resist the conclusion that flocculation of the clayey matter suspended in the water has been effected by electrolytes such as calcium carbonate.

Before reviewing the general conclusions as to the genesis of these bands, reference may be made to evidence seen in the upper part of the Upper Dwyka boulder shales at Douglas. In a small stream-section near the Post Office, the upper shales towards the head of the stream contained numerous boulders of tillite-like material resembling the hard bands of De Kalk and other areas described. These boulders resembled the bands of the Hospital Farm section, inasmuch as they displayed no marked layering and were highly calcareous.

Dr. Brammall's petrological report on one of these " erratics " emphasises the fact that there is little or no " clay body," but that the rock fragments are embedded in calcite as a cementing medium. The petrological assemblage of fragments is very similar to those of the De Kalk and Hospital Farm specimens described above. These " boulders " display the same conditions of deposition in the shales as the ordinary type of erratic seen at De Kalk and elsewhere.

The conditions immediately following the deposition of the Douglas " boulders " are explained by the nature of the overlying beds. These consist of 5 feet of varve shales overlain by 1 foot of a banded harder shale, highly calcareous, and containing cone-in-cone structure.

Reviewing the evidence, certain conclusions as to the genesis of the " hard bands " in the Upper Dwyka boulder shales appear justified. They represent the various stages of deposition of englacial material from floating ice derived from land glaciers, in water highly charged with calcareous matter due to derivation of material from the dolomitic Kaap plateau. As a result of summer melting, the sheets of floating ice (pack ice or shore ice) melted downwards to a point when the volume of ice was insufficient to float the load of englacial material. When this point was reached the ice rafts sank on the sea or lake floor of glacial mud. When this process was rapid there was no opportunity for rearrangement of the englacial material, but if the process was sufficiently slow to disintegrate the bands of detritus, layering and pellets were formed (Pl. XI, C and D).

An illustration of the Laingsburg tillite (Pl. XI, A) is given for comparison. In view of the evidence submitted in this paper, it may be regarded as due to deposition of englacial detritus from floating ice. To the student of the Pleistocene drift deposits of the north-west of Europe, the evidence is extremely suggestive as throwing light on the controversial question of the genesis of the marginal sheets of boulder clay associated in some cases with deposits containing an anomalous fauna. With the South African evidence may be compared Dr. Whittard's recent work on the Greenland Pack Ice (14), concerned with the capacity of floating ice to distribute shore shells over wide areas of the sea bed.

B. Infra-Formational Folding of Deposits at De Kalk.

The evidence of infra-formational folding developed in the lower part of the De Kalk section beneath the limestone band (H.B.) were of especial interest to the author in view of the magnificent examples of glacial disturbances due to land ice which occur in the disturbed Pleistocene deposits of Europe and America.

An admirable preparation for the study of the De Kalk evidence was afforded to the author owing to the courtesy of Professor S. J. Shand, who arranged a special visit to the unique example of infra-formational folding in the Table Mountain Series of the Stellenbosch mountains, under the leadership of Dr. A. V. Krige (9, p. 21). This folded zone has a thickness of from 150 to at least 300 feet, and is always underlain as well as unconformably overlain by undisturbed beds. The structure differs essentially from that produced by land ice, for whereas the latter is associated with a considerable ice load and produces structure by differential movement of ice charged with lenticles of englacial material, the disturbances at Stellenbosch require essentially different conditions for their genesis, as they display movement *en masse* of the disturbed beds. The authors of the paper

state : " The symmetry of the folds seen by us, with their broad synclines and steep, narrow anticlines, often truncated, but rarely overfolded, show that there could not have been any considerable load above the beds when they were folded. This condition would have been satisfied if the folding occurred under water, where the advancing ice sheet was not touching the bottom but floating. Where the ice rested upon the unconsolidated and waterlogged sediments it produced a hydrostatic pressure within them, and as it advanced it exerted a forward thrust upon the surface beds."

The disturbances at De Kalk, although on a small scale, are essentially similar to those of the Stellenbosch area. But whereas in the latter area a section may be studied in the general direction of ice movement, at De Kalk the section is oblique to the general strike of the beds. In the section, Pl. XII, the part between 0 and 1300 feet is more nearly in line with the direction of strike. In this zone beautiful **S**-shaped folds occur, and a general buttressing of the disturbed beds against contorted shales. From the point 1300 to 2000 feet overfolds are developed, and then up to the point 6500 feet follow a series of anticlines and synclines, the limbs of which crop out along the left bank of the Riet River. The strike of the limbs of the anticlines and synclines varies from N.W.–S.E. to N.N.W.–S.S.E. (magnetic), the latter direction being dominant and pointing to a general movement from the N.E. This structure supports the view that the disturbances were due to the rucking up of the floor of unconsolidated deposits by floating ice, which stranded against a low bank of the sea or lake-floor. The frontage of the advancing ice which produced the disturbances would therefore be about a mile, and the advance of the ice was subsequent to the deposition of the disturbed shales and intercalated hard calcareous bands of tillite-like material. The hard limestone bed (H.B.) (Pl. IX, B) which rests unconformably on the disturbed zone, represents extremely tranquil conditions of deposition. The South African evidence forms accordingly a striking corollary to the results obtained by geographical exploration of Polar Seas. The general conditions prevailing in this district during the concluding phases of deglaciation have been so concisely and admirably summarised that the author feels that he cannot do better than quote the following :—

" Judging from the evidence in this area, it seems to me that all these various deposits have almost without exception been formed *beyond the ice front and during its retreat* in a northerly or north-easterly direction. Over the high ground the glacial material would be deposited continuously by the melting of the ice, etc., while in the valleys (*e.g.* Harts-Vaal) where the old floor was submerged the deposit would be more or less regularly bedded. Beyond the ice front material would be deposited by floating ice, while sub-glacial streams would transport gritty and finely divided stuff . . .

and an advance would result in the ploughing up of the earlier deposits and the production of boulder pavements" (4, p. 119).

In conclusion, the author expresses his thanks to Miss Wilman of the Kimberley Museum for enthusiastic help, and to Mr. A. M. Duggan Cronin for his excellent photographs; to Dr. A. L. du Toit for his admirable papers and for the *résumé* of the Nooitgedacht erratics included in this paper, and to his colleague, Dr. Alfred Brammall, for the petrological reports, and to Mr. G. S. Sweeting for taking the photographs. The author is especially indebted to the Council of the British Association for a grant to attend the South African Meeting, 1929, and to the Royal Society for a Government grant, and also a grant in aid of publication. The working out of the results was completed in the Geological Department of the Imperial College of Science, London, with the permission of Professor W. W. Watts, F.R.S., and his successor, Professor P. G. H. Boswell, F.R.S.

Summary.

The evidence in Griqualand West contributes notably to our knowledge of glacial erosion and sedimentation.

1. *Nooitgedacht* is a classical area for the study of the progressive erosion of the topographical features by land ice. The rock basin contains large outcrops of jointed diabase which display excellent examples of crag-and-tail phenomena showing in plan the stream-line form. In each case the iceward limb is characterised by striations, polishing, grooves, shelves, chatter marks, and relief polishing where amygdaloids occur, the surface having formed the lubricated sole of a thrust-plane for ice which functioned as a soft abrasive. The iceward limb increases in length with progressive decrease in height of the obstruction to ice movement, and terminates at the crest of a sigmoid curve. Abrasion was therefore the dominant form of erosion in the later stages of ice action. The leeward limb is associated with "pluck," more especially in the larger outcrops. This type of erosion characterises the earlier stages of ice action.

2. *De Kalk.*—The section at De Kalk is a type example of the sedimentation of glacial detritus in water. The hard bands of tillite-like material represent englacial substance from land ice which has been deposited as cakes from floating ice. With rapid deposition the structure has remained intact; with slower deposition disintegration is shown by incipient layering and the precipitation of the oval-shaped pellets now seen in the ground-mass.

LITERATURE.

(1) 1872. Tiddeman, R.—"Ice-sheet in North Lancashire," Quart. Journ. Geol. Soc., vol. xxviii, pp. 471–491.

(2) 1903. Annual Report Geol. Com. Cape of Good Hope, pp. 18–25; "Eland's Vlei Boulder-Pavement," pp. 21–22.

(3) 1904. Molengraaff, G. A. F.—"Geology of the Transvaal," Edinburgh and Johannesburg. Riverton *roches-moutonnées*, p. 67.

(4) 1906. Annual Report Geol. Com. C.G.H., pp. 108–121; "De Kalk," p. 117; "General Summary," p. 119.

(5) 1909. Rogers, A. W., and du Toit, A. L.—An Introduction to the Geology of Cape Colony (Longmans Green & Co.), chap. vii, p. 117, "Striated Pavement, Eland's Vlei."

(6) 1913. Evans, J. W.—"The Wearing Down of the Rocks," Proc. Geol. Assoc., vol. xxiv; "The Eroding Action of Ice," *ibid.*, pp. 261–300.

(7) 1921. Beilby, Sir George.—Aggregation and Flow of Solids (Macmillan & Co.).

(8) 1922. Du Toit, Alex. L.—"The Carboniferous Glaciation of South Africa," Trans. Geol. Soc. South Africa, vol. xxiv, pp. 188–227.

(9) 1925. Haughton, S. H., Krige, L. J., and Krige, A. V.—"On Infra-formational Folding connected with the Glacial Bed in the Table Mountain Sandstone," Trans. Geol. Soc. South Africa, vol. xxviii, pp. 19–25.

(10) 1926. Du Toit, Alex. L.—The Geology of South Africa (Oliver & Boyd, London), chap. xii, "The Dwyka Series," pp. 205–215.

(11) 1928. Problems of Polar Research, Amer. Geog. Soc., New York.
A. Kolchak.—"The Arctic Pack," etc., pp. 125–141.
N. A. Transehe.—"The Ice Cover of the Arctic Sea," etc., pp. 91–123.

(12) 1929. Lovegrove, E. J.—"Attrition Tests of British Road Stones," Mem. Geol. Survey.

(13) 1929. Du Toit, Alex. L.—"A Brief Review of the Dwyka Glaciation of South Africa," vol. ii, Compte Rendu XV Internat. Geol. Congress, South Africa, pp. 90–102; "Varve Shales," pp. 94–95.

(14) 1930. Fuchs, V. E., and Whittard, W. F.—"The East Greenland Pack Ice and the Significance of its Derived Shells," Geog. Journ., vol. lxxvi, pp. 419–425.

EXPLANATION OF PLATES.

Plate III.

A. Nooitgedacht Farm. The course of the River Vaal is outlined by the trees. In middle distance profile view of glaciated rock with crag-and-tail phenomena.

B. Nearer view of iceward face of glaciated boss of jointed diabase. See A, middle foreground, right-hand side. (See fig. 3, *f*, at point B.)

Plate IV.

A. Striated rock surface about half a mile east of the farm and adjacent to the *roche-moutonnée* of Plate VI, A. Chatter groove to right of hammer.

B. Striated rock, showing differential abrasion, on the slope of the hill near the farm. The upper part of the rock contains an infilled "gas blow-hole" which has been abraded to form a bevelled ridge.

PLATE V.

A. Glaciated rock near farm, shown in middle foreground of Plate III, A. Glaciated shelves, figure is pointing in the direction of strice. Tillite with erratics in foreground.
B. Glaciated and grooved rock.
C. Glacial groove, 24 feet long, 5 feet wide, and 1 foot 2 inches deep, extends from figure to foreground. Situation south-east of house.

PLATE VI.

A. *Roche-moutonnée* with erratics, situated about half a mile east of the farmhouse. Iceward limb shown in photograph, but pluck and tail are well developed on leeward limb not shown. (See fig. 3, profile C and B.)
B. *Roche-moutonnée* about half a mile east of house and near A. Figure on left marks position of commencement of pluck. Profile shown of side of exposure in fig. 3 (*d*), the direction being oblique to that of striations. Longitudinal profile in fig. 3 (*e*) (crag and tail).
C. Drie Kops Eiland, on Riet River. Pluck associated with joints on leeward limb of a boss of rock.

PLATE VII.

Nooitgedacht Varve Shales.

A. Photo of hand specimen obtained from outcrop shown in D.
B. Photo-micrograph of varve shale.
C. Section, 300 yards east of house. Shows 1 foot of varves intercalated in Dwyka. The varves contained a boulder and showed disturbance.
D. Varve shales horizontal at the hammer, but inclined in face behind to left, where they are adjacent to a glaciated boss of rock.

PLATE VIII.

Riverton Glacial Pavement.

A. Pavement showing "picture-frame moulding" of pale grey varves.
B. Photo of cross-section of hand specimen from A. Note that the syncline of the interior coincides with that of the surface. Lateral squeezing has produced the lenticle to the right.
C. Photo-micrograph of lower part of the specimen B (central portion). Shows lamination of contained fragments, which are orientated with their longer axes at right angles to a vertical pressure.

PLATE IX.

A. De Kalk. Part of an S-shaped fold of boulder conglomerate from Bed 1 of Plate XII.
B. De Kalk. Photo-micrograph of the limestone hard band. (H.B.) of Plate XII.
C. Drie Kops Eiland. Hard band of "tillite-like material" in lower part of the Upper Dwyka boulder shales, adjacent to a boss of rock near right of photograph. Shows association with boulders, and with shales beneath.

PLATE X.

A and B. Tillite from Nooitgedacht. Typical land-formed tillite with angular fragments.
C. Douglas "tillite-like" erratic or pseudo boulder, from Dwyka shales.
D. Hospital Farm, Prieska. Hard band from Dwyka shales, full of angular fragments.

PLATE XI.

A. Laingsburg tillite. Note rounded form of smaller particles.
B. De Kalk, hard band. Rounded small particles but no evidence of layering. Bed 1 of Plate X.
C. De Kalk, hard band as in B. Pellets well developed.
D. De Kalk, as in B and C. Distinct evidence of layering. Pellets of various sizes, the largest being at the bottom of the photo.

PLATE XII.

Section at De Kalk, Riet River.

The " dots " in Bed 2 are conventional signs only, indicating the presence of boulders in the shales. The larger dots indicate zones where erratics are either exceptionally large or are more numerous. The portion of the section between points 4200 and 5500 feet, or nearly ¼ mile, was obscure, hence it is difficult to decide if Bed 3 continues to overlie Bed 2, or whether the two beds merge into one another in the area not drawn. Near the top of the section, at 2800 feet, varve shales appear to be developed, but the position was inaccessible. Between the points 2100 and 3400 feet the outcrops may be prolonged below the base line adopted in the section. In a few cases hard bands only outcropped in the bed of the river.

A.

B.

Neill & Co., Ltd.

A.

B.

Neill & Co., Ltd.

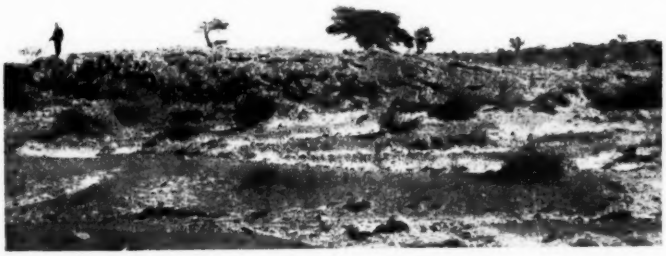
A.

B.

C.

Neill & Co., Ltd.

A.

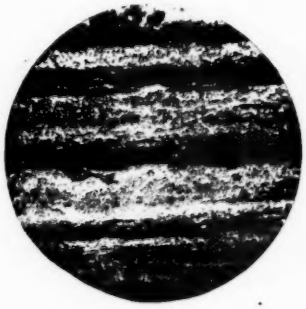


B.

C.

Neill & Co., Ltd.

A.



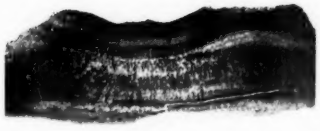
B.

C.

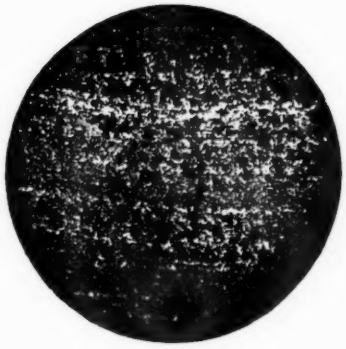
D.

Neill & Co., Ltd.

A.



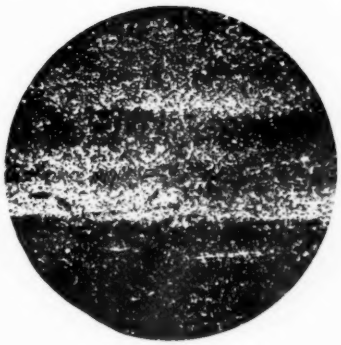
B.



C.

Neill & Co., Ltd.

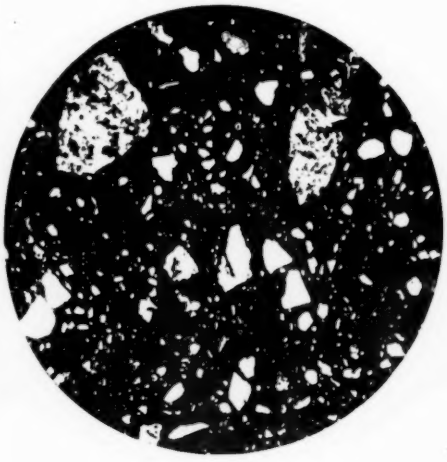
A.



B.

C.

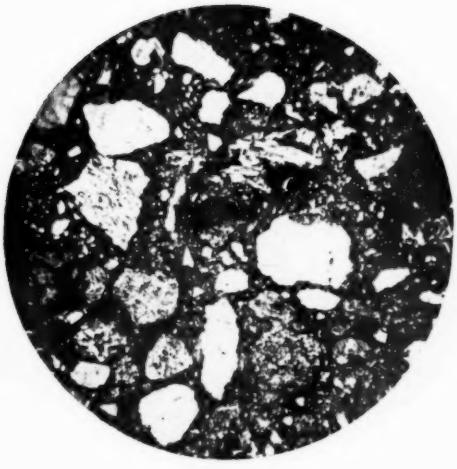
Neill & Co., Ltd.



A.

B.

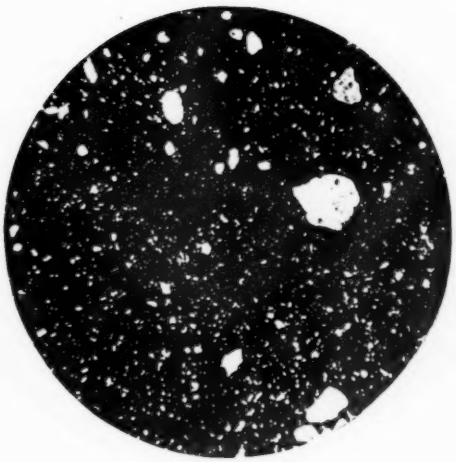
C.



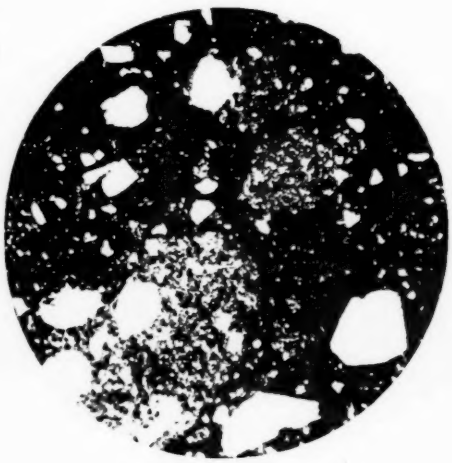
D.

Neill & Co., Ltd.

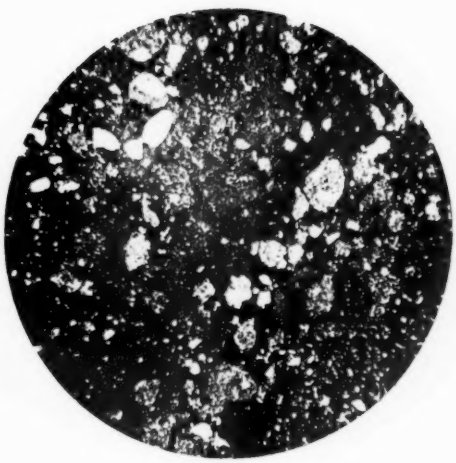
A.



B.



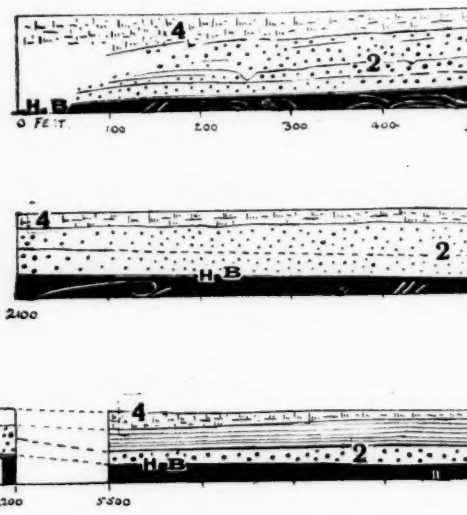
C.



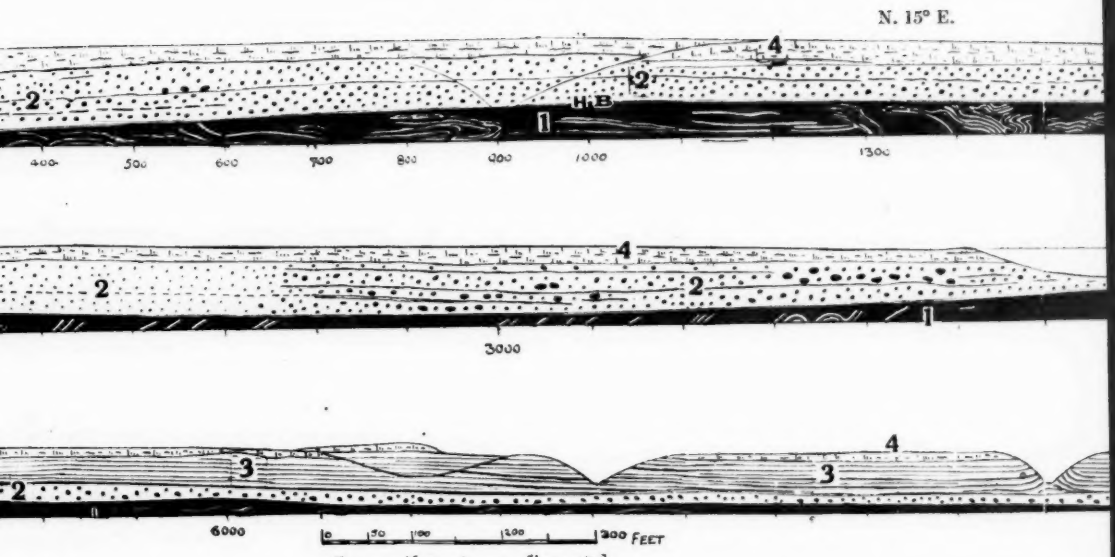
D.

Neill & Co., Ltd.

S. 15° W.

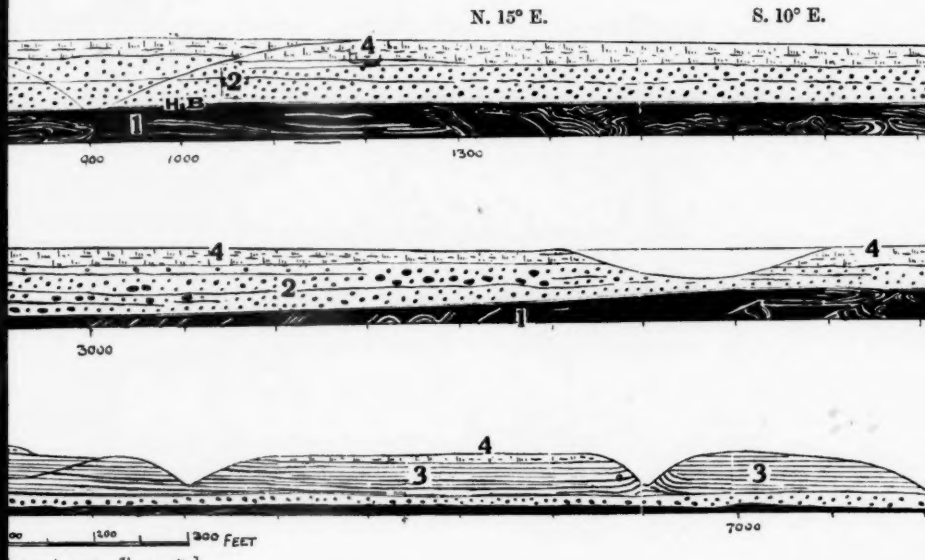


4. Calcareous
3. Dark, fine-g
2. Black shale
1. Boulder sha



SECTION AT DE KALK, RIET RIVER, 1929.

4. Calcareous tufa capped by gravel.
3. Dark, fine-grained sandstones and flagstones.
2. Black shales containing scattered boulders and thin limestones. H.B. = hard-band, composed of finely bedded limestone, which lies
1. Boulder shales intercalated with " dyke-like " calcareous slabs of " tillite-like " material, highly disturbed.

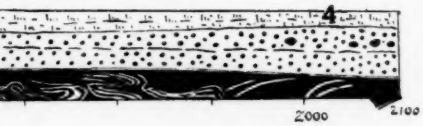


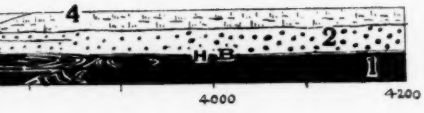
SECTION AT DE KALK, RIET RIVER, 1929.

thin limestones. H.B. = hard-band, composed of finely bedded limestone, which lies unconformably on 1.
alcareous slabs of " tillite-like " material, highly disturbed.

Plate XII.

E.

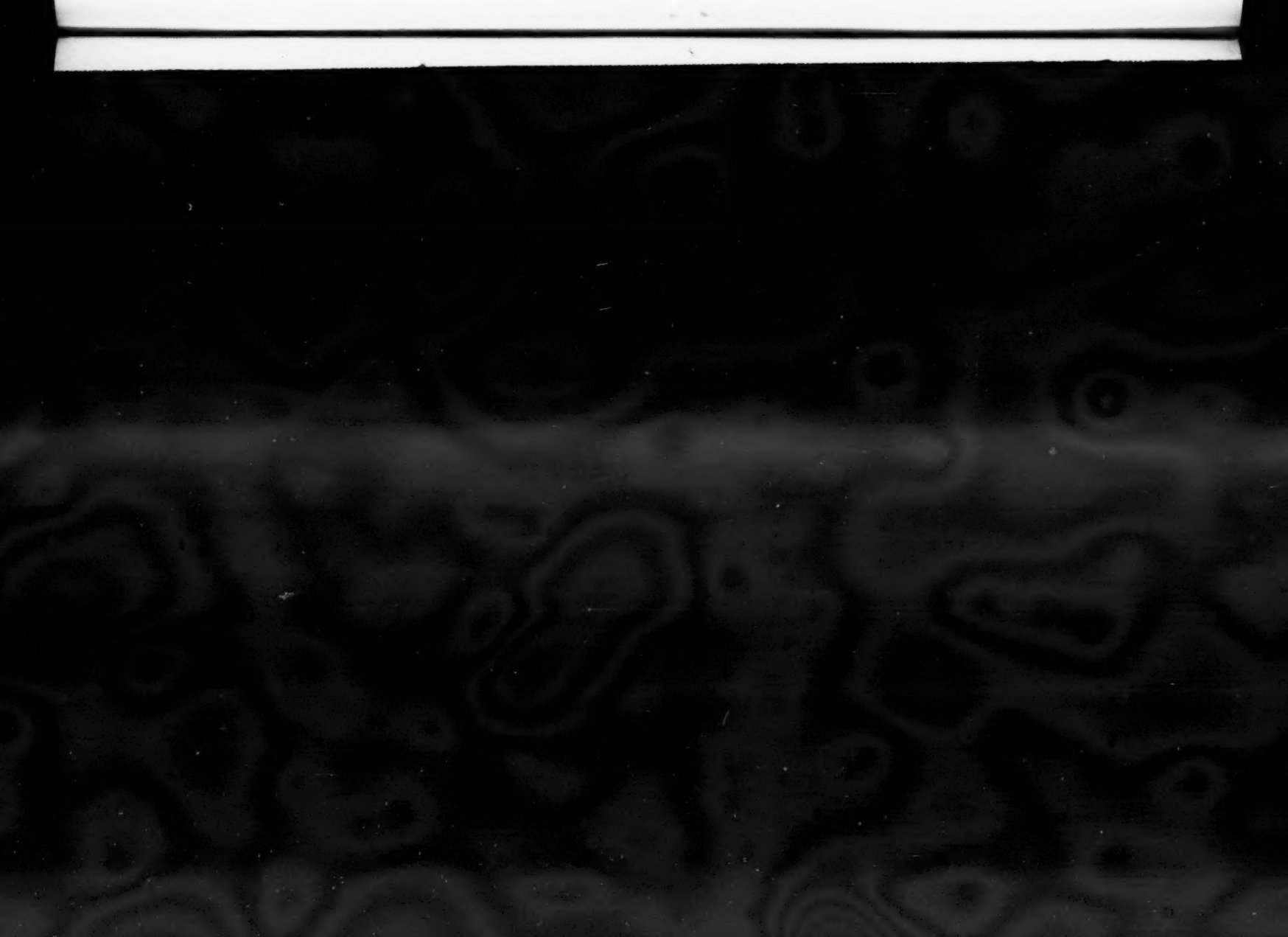




N. 10° W.

ably on 1.

Neill & Co., Ltd.



THE STABILITY OF BROMIC ACID AND ITS USE FOR THE DETERMINATION OF BROMIDE IN BROMATES AND IN CHLORIDES.

By W. Pugh, Ph.D.

A considerable extension of the use of potassium bromate as a volumetric reagent has recently been proposed. Smith (1), in the first of a series of articles on this subject, pointed out the unexpected stability of bromic acid at the boiling-point. He demonstrated this by boiling small quantities of potassium bromate with dilute solutions of various acids and determining the bromic acid in the boiled liquid with potassium iodide and thiosulphate. He then treated various mixtures of potassium bromide and potassium bromate in the same way, and found that, under the conditions employed, the amount of bromine lost corresponded exactly with that required by the equation :—

$$5HBr + HBrO_3 \longrightarrow 3Br_2 + 3H_2O.$$

In the presence of nitric and perchloric acids there was no indication of any decomposition of bromic acid. In all his analyses, however, he used decinormal solutions, and he regarded his results as evidence of complete absence of decomposition. He then used the method for estimating traces of potassium bromide, of the order of 0·3 mgrm., in half-gram samples of potassium bromate. In no case did Smith estimate the amount of decomposition, if any, by absorbing the bromine liberated.

The present author recently had occasion to determine the bromide content of a sample of potassium bromate, and was led to the conclusion that the error in the method employed by Smith is far too great to enable it to be used for determining small amounts of bromide. The bromide produced by decomposition of the bromate often exceeds the trace of bromide present as impurity.

It was therefore resolved to re-examine the stability of bromic acid, and to determine, if possible, the precise conditions under which traces of bromide may be estimated.

Materials Employed.—The potassium bromate used was a sample of Merck's reagent. It was recrystallised before use and tested for halide as follows :—(1) a hot, slightly acid solution was treated with a few drops

of silver nitrate; (2) a half-gram portion was dissolved in about 50 c.c. of water, acidified with nitric acid, and extracted with carbon tetrachloride. The lower layer was then run into alkaline peroxide, acidified, and treated with silver nitrate. No trace of opalescence could be detected in either case. The potassium bromide used was Kahlbaum's quality.

Both salts were dried at 110° and made up into stock solutions of known concentration. Measured quantities of these solutions were taken for analysis.

All the analyses quoted herein were made with standardised measuring instruments, which could be read to within 0·02 c.c. The quantities of material taken were adjusted so that this represented an error not greater than 0·1 per cent.

Testing the Stability of Bromic Acid in Boiling Solution.—The method consisted in distilling acidulated potassium bromate, with and without potassium bromide, and collecting the bromine liberated in alkaline hydrogen peroxide. The bromide so formed was estimated by the Volhard method. In this connection, it should be noted that hydrogen peroxide has a slight effect on the consumption of thiocyanate. This amounts to about 0·1 c.c. It was therefore necessary to standardise the solutions under precisely the same conditions and in the presence of the same amount of hydrogen peroxide as used for the absorption of the bromine. All the reagents employed were tested beforehand for traces of halide.

The apparatus consisted of a 250 c.c. round-bottom flask fitted with a ground-in head carrying a delivery tube. To the head was also sealed a long glass tube reaching to the bottom of the flask and terminating above in a small funnel. This served for the admission of acid and a current of air during the distillation. The delivery tube was connected by means of a ground-glass joint to an 8-bulb absorption apparatus, which was also fitted with a cooling jacket. The absorption system was charged with 10 c.c. of N caustic soda and 2 c.c. of 6 per cent. hydrogen peroxide and 30 c.c. of water.

Measured quantities of bromide and bromate were placed in the flask and diluted to 100 c.c. A measured quantity of acid was then introduced and a slow current of air was aspirated through the liquid. The temperature was gradually raised to the boiling-point, and boiling was continued for ten minutes after the colour had disappeared from the flask. Table I shows the results obtained with sulphuric acid.

These results confirm the conclusions reached by Smith, namely that appreciable decomposition of bromic acid takes place in presence of sulphuric acid. The results indicate, moreover, that the extent of decomposition increases with increasing concentration of bromic acid. This latter fact is more clearly seen in Table II, which shows the amount of bromine,

reported as potassium bromide, liberated when potassium bromate alone was distilled with sulphuric acid for ten minutes.

TABLE I.—*Effect of* H_2SO_4 (0·2N) *on the Reaction between Bromic and Hydrobromic Acids at the Boiling-point. Total volume* 100 *c.c.*

$KBrO_3$ taken (grms.).	KBr taken (grms.).	KBr found * (grms.).	Difference (per cent.).
0·07500	0·1500	0·1499	−0·06
·07500	·07500	·07505	+0·06
·07500	·06000	·06010	+0·16
·1500	·07500	·07518	+0·25
·3000	·07500	·07520	+0·27
0·2250	·01875	·01884	+0·5
1·856	·01875	·0206	+9·9

* % of total bromide.

TABLE II.—*Effect of Sulphuric Acid and Bromic Acid Concentration on the Stability of Bromic Acid at the Boiling-point.*

H_2SO_4 normality.	$KBrO_3$ (grms./100 c.c.).	Mgrms. KBr found in distillate.
0·2	1·86	3·60
·2	1·00	1·30
·2	0·50	0·4
·2	0·25	0·15
·4	0·25	0·4

Table III gives the results obtained by the same method, using nitric acid instead of sulphuric acid.

These results show that bromic acid is not stable under conditions of distillation with nitric acid. They show that prolonged distillation is necessary to remove the whole of the bromine liberated, and under these conditions there is appreciable decomposition of bromic acid. The method is therefore not suitable for estimating traces of bromine.

Testing the Stability of Bromic Acid in Cold Dilute Solution.—As long ago as 1891 it was pointed out that solutions of potassium bromate slightly acidified with sulphuric acid were stable under ordinary conditions of storage for quite long periods of time (2).

TABLE III.—*Effect of* HNO_3(N) *on the Stability of Bromic Acid at the Boiling-point.*

KBr taken (grms.).	$KBrO_3$ (grms.).	Period of boiling (min.).	KBr found.*	Difference (per cent).
0·1190	0·120	5	0·1145	−3·8
·1190	·24	5	·1146	−3·7
·1190	·50	5	·110	−7·5
·1190	·120	10	·1184	−0·5
·1190	·24	10	·1182	−0·7
·1190	·50	10	·1183	−0·6
·1190	1·00	10	·1190	±0·0
·1190	0·120	20	·1194	+0·3
·1190	·24	20	·1196	+0·5
·1190	·50	20	·1206	+1·3
·0059	·50	20	·00645	+9·3
..	·50	20	·0004	..
..	·50	10	·0003	..
..	·25	20	·00038	..

* % of total bromide found.

In order to determine whether any decomposition could be detected, the author acidified several portions of potassium bromate and extracted the liquid several times with small portions of carbon tetrachloride. Provided sufficient time, from 5 to 10 minutes, was given for complete separation of the liquid phases, no trace of bromide could be detected with silver nitrate after shaking the carbon tetrachloride layer with alkaline peroxide. However, on testing the carbon tetrachloride layer for bromine with potassium iodide, rather unexpected results were obtained. With a neutral solution of iodide and starch there was no blue colour developed, or at most only the faintest evidence in some cases. This proved the absence of free bromine. Upon acidifying the solution, however, a deep blue colour was always developed. The potassium iodide was tested and found to be free from iodate. It appears that traces of potassium bromate are carried through with the carbon tetrachloride.

Whether this trace has any influence on the accuracy of the determination of bromide by means of bromate was examined by extracting various mixtures of bromide and bromate, acidified with nitric or sulphuric acid, with carbon tetrachloride. The results given in Table IV show that it has no influence when the bromine is estimated by Volhard's method or by the iodimetric method in neutral solution.

TABLE IV.—*Extraction of Acidified Bromide-bromate Mixtures with Carbon Tetrachloride.*

$KBrO_3$ taken (grms.).	KBr taken (mgrms.).	KBr found (mgrms.).
0·5	1·19	1·18
..	..	1·17*
2·0	1·19	1·17*
0·5	2·38	2·34*
0·5	5·95	6·00
..	..	5·97*
0·5	11·90	11·88
0·5	23·80	23·76
..	..	23·80*
0·25	59·50	59·46

* By iodimetric method.

The extraction was carried out in the separating funnel of a Schramm's bromination apparatus. The mixed bromide-bromate solution was diluted to about 40 c.c. Ten c.c. of carbon tetrachloride and 5 c.c. of dilute acid were added, and extraction was continued until the tetrachloride layer became perfectly colourless. A total of 30 c.c. of carbon tetrachloride was sufficient for quantities of bromide less than 20 milligrams. The extracts were run off into the flask under alkaline hydrogen peroxide, or, in some cases, under a solution of potassium iodide. In the latter case the iodine liberated was estimated in neutral solution by titration with thiosulphate. The values obtained by the two methods agreed well in general, but it is rather more difficult to detect the end-point with thiosulphate when the amount of bromine is very small.

The Influence of Chlorides.—Hydrochloric acid is not to be expected to reduce bromic acid, but Smith (*loc. cit.*) has shown that, although traces have no influence, quantities of the order of 10 milligrams or more have an appreciable effect at the boiling-point.

The effect of different quantities of chloride was therefore investigated in the cold, because it was thought that if relatively large amounts are without action on bromic acid, this would lead to an excellent method for estimating bromide in the presence of chloride. Accordingly, known weights of potassium chloride and potassium bromide were treated with excess of potassium bromate, acidified and extracted with carbon tetrachloride. The weights of bromide taken and actually found by this method are compared in Table V.

TABLE V.—*The Effect of Chlorides on Bromic Acid in the Cold.*

$KBrO_3$ used (grms.).	KCl used (mgrms.).	NaCl	KBr used (mgrms.).	KBr found (mgrms.).
0·25	12·0		59·5	59·4
0·10	14·8		119·0	119·1
·10	37·0		119·0	118·9
·10	74·0		119·0	119·1
·10	148·0		119·0	119·1
·10		200	119·0	121·0
·10		200	119·0	119·9*
·10		200	119·0	119·3†

* NaCl recrystallised once.
† NaCl recrystallised twice.

It is evident that large quantities of chloride do not influence the degree of accuracy attainable in the estimation of bromide by this method. The sodium chloride employed evidently contained some impurity, the effect of which was gradually eliminated by recrystallisation. Ammonium salts, however, interfere considerably and must be excluded.

LITERATURE CITED.

(1) SMITH.—Journ. Amer. Chem. Soc., 1923, vol. xlv, pp. 1115, 1417, 1666; *ibid.*, 1924, xlvi, p. 1577; *ibid.*, 1931, vol. liii, p. 2091.
(2) FEIT and KUBIERSCHKY.—Chem. Ztg., 1891, vol. xv, p. 351.

A SEASONAL STUDY OF THE MICROFLORA AND MICROFAUNA OF FLORIDA LAKE, JOHANNESBURG, TRANSVAAL.

By Johanna F. M. Schuurman,
Department of Zoology, University of the Witwatersrand.

(With Plate XIII, one Text-figure, and Graphs I–VII.)

Introduction.

The present report is, as far as the author is aware, the first seasonal study of both the zoo- and phytoplankton of a freshwater locality conducted in the southern hemisphere. Section I deals with the geographical position of the lake and its chemical and physical condition. In Section II the technique is described; in Section III observations on the seasonal succession are brought forward; while Section IV deals with the vertical migration as observed during one diurnal period. In Section V certain special seasonal phenomena are briefly considered. Section VI follows as a general discussion, in which a comparison with other localities is made.

Acknowledgments.

This investigation was suggested by Mr. G. E. Hutchinson, formerly Senior Lecturer in the Department of Zoology at the University of the Witwatersrand, and Mrs. G. E. Hutchinson, to whom my sincerest thanks are hereby given for their assistance. Abstracts of papers, not available to me in South Africa, were made by them in the United States of America, and they prepared the microphotographs at the Osborn Zoological Laboratory of Yale University.

I should also like to take this opportunity of thanking Miss E. Stephens and Professor T. A. Stephenson of the University of Cape Town for their helpful criticism and advice in connection with the arrangement of my results.

For identification of the species belonging to the various groups, my grateful thanks are due to Mr. D. Bryce (Rotifera), Mr. F. Kiefer (Copepoda), Dr. O. Herr (Cladocera), Dr. K. Viets (Hydracarina), Dr. A. Hastings (Polyzoa), Dr. K. Höll (*Peridinium* spp.), and Miss F. Rich (Phytoplankton).

My grateful thanks are also due to the Roodepoort-Maraisburg Municipal Council who have, over a period of two years, granted me the free use of a boat on Florida Lake to take my collections.

I also wish to acknowledge the receipt of a grant from the Research Grant Board of the Union of South Africa which has enabled me to carry out this work.

Section I.

DESCRIPTION OF THE LAKE.

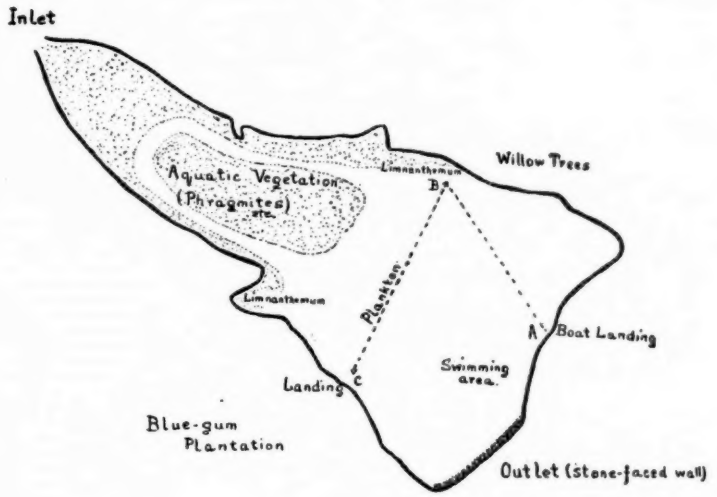
Florida Lake is situated in the Roodepoort-Maraisburg Municipal boundary area, about 9 miles west of Johannesburg, at an altitude of about 5700 feet above sea-level and about 28° long. and 26° 5′ lat. The lake lies on the Jeppestown series (shales with sandstone and quartzites) of the lower Witwatersrand beds. It is an artificial lake, roughly triangular in shape, being approximately ½ mile long and ⅓ mile broad. The depth at the stone-faced wall (the deepest portion) is roughly 20 feet, when the lake is full, but has been stated to fall as low as 5 feet. During the two years of investigation this depth varied roughly from 16 to 20 feet, according to the time of the year. The mean annual rainfall is approximately 30 inches (760 mm.), more than three-quarters of which usually falls during the summer (November–March), and the level of the water varies accordingly. The banks of the lake are natural, excepting for a stone-faced wall at the outlet; at the inlet side the shores are weedy, while the central portion of this area is occupied by Phragmites (*cf.* figure). The bottom of the lake is composed of black mud.

The lake supports large numbers of fish (mostly carp, barbel, and "gilliminkies"), and birds of which the following have been observed at various times: moorhen, dabchick, king reedhen, black rail, coot, vlei duiker, grey heron, snake bird, squacco heron, finks, and small passerines. Florida Lake is used extensively for swimming during the summer months, when visitors also have the use of boats. Although snails are found amongst the marginal vegetation, the records of the Institute for Medical Research at Johannesburg show that none infected with Schistosoma have as yet been recorded.

The marginal **plant life** of the lake is very rich, but no definite study has been made of this; the following list has been very kindly furnished by Miss D. Weintroub from the Department of Botany: Charophyta—*Chara stachymorpha* Gant., *Nitella doidgeae* Grov. and Steph. Flowering Plants—*Phragmites communis* Linn., *Typha australis* Schum. and Thon., *Scirpus corymbosus* Rottb., *Polygonum tomentosum* Willd., *P. serrulatum*

Lag., *P. glutinosum* Meisn. var. *capense*, *Juncus* spp., *Cyperus* sp., *Potamogeton badius* Hagstr., *P. nodosus* Poir., *P. javanicus* Hassk., *Largarosiphon muscoides* Harv., *L. major* Moss, *Limnanthemum thunbergianum* Griseb.

The **waterbugs** from Florida Lake have been described by G. E. Hutchinson (Ann. S.A. Museum, vol. xxv, pt. 3), who lists the following species : *Anisops gracilis* Hutch., *Plea* (*Paraplea*) *pullula* Stäl, *P.* (*Paraplea*) *piccinina* Hutch., *Micronecta scutellaris* (Stäl), *M. dorothea* Hutch., *Sigara*



FLORIDA LAKE.

wahlbergi Lundbl. (=*contortuplicata* Hutch. nec Kirk.). The insect fauna has otherwise not been investigated.

Two species of **Polyzoa**, *Lophopodella capensis* (Sollas) and *Plumatella emarginata* Allman, were found to be present mainly on the stems of *Phragmites communis* from the beginning of May until August.

CHEMICAL AND PHYSICAL DATA FOR THE WATER.

The temperature range for the period of investigation lies between 22·5° C. (January) and 7·5° C. (June) ; the pH range varies from 6·2 to 7·0. The filtered water is clear and colourless, but in bulk it has a greenish

appearance, and at times when *Dinobryon* and *Melosira* are very abundant a small sample may also have a slight greenish tint.

An attempt was made to determine relative values for light penetration by use of a billiard ball cut in half and suspended flat side up from a thread. The distance from the surface of the water at which the ball disappeared from sight was recorded in centimetres. As stated in "A Contribution to the Biology of Pans and other Inland Waters of South Africa" (Hutchinson, Pickford, and Schuurman, *in press*), these values have been equated with those given by a Secchi disc, and it was found that 10 cm. corresponded to 11·5 cm. on the standard scale. The turbidity of the water was only studied at the time observations were made on the vertical migration during one diurnal period (see Graph I), and on 23/6/28 when the relative values were found to be 32 cm. in the shade and 40 cm. in the sun.

The available chemical data are presented in Table I. The chloride content of the water is very low, while it contains a small yet disproportionately large amount of sulphate (30 to 60 grms. per litre), probably due to the proximity of gold mines, though it can hardly be said to be contaminated (G. E. Hutchinson *in litt.*). In general the water of Florida Lake is probably to be classified as eutrophic or mesotrophic.

The chemical data are, with the exception of pH determinations, based on volumetric and colorimetric analyses made by G. E. Hutchinson and G. E. Pickford in the Department of Chemistry of the University of the Witwatersrand, by kind permission of Professor J. A. Wilkinson. The methods employed are described elsewhere in a paper dealing with other South African localities (Hutchinson, Pickford, and Schuurman, *forthcoming publication*). Data for two other artificial lakes, treated more fully in that work, are presented along with those for Florida Lake in order that comparisons can be made between these three localities.

The chemical composition of these waters presents few peculiarities when compared with that of moderately small soft-water lakes in other parts of the world. Florida Lake is remarkable for the relatively large, if variable, amounts of sulphate dissolved in its waters. Evidence to be presented elsewhere suggests that this is derived from the mine-dumps in the vicinity of the lake. The amount present is, however, negligible when compared with the highly contaminated acid sulphate waters in certain other Witwatersrand localities, and it is improbable that the sulphate content of Florida Lake has any biological significance. Silicate, nitrate, nitrite, and phosphate have all been detected in the water of Florida Lake, and though the amounts present are small when compared with values obtained for many other inland waters in South Africa, it is highly improbable that any biological deficiency of these substances occurs. The

values given for dissolved oxygen at the surface of Florida Lake are curiously variable, the variability being doubtless due to the shallowness of the lake, the large amount of organic mud on the bottom, and also to variation in the amount of oxygen liberated during photosynthesis, the latter being dependent upon (*a*) phytoplankton variation and (*b*) light-intensity variation. It should be noted that at an altitude of 5700 feet and a temperature of 20° C. the solubility of oxygen in water at mean atmospheric pressure is 7·4 mgrms. per litre.

TABLE I.

ARTIFICIAL LAKES IN THE TRANSVAAL, SOUTH AFRICA.

1. FLORIDA LAKE, 1928.

	Temp.	pH.	Chloride normality.	Alk. res. normality.	Diss. O_2 mgrms./litre.	Silicate mgrms./litre.†	NO_2 mgrms./litre.	NO_3 mgrms./litre.	P_2O_5 mgrms./litre.	SO_4 mgrms./litre.	Fe mgrms./litre.	Mg mgrms./litre.
24th Feb. 1928	21·0° C.	6·7	·0003	..	7·5	..	..	..	..	60	..	..
3rd March 1928	22·5° C.	6·79	·00025	..	5·4	..	..	..	..	30	..	..
10th March 1928	21·0° C.	6·79	..	..	6·30	..	..	..	..	..	..	..
17th March 1928	20·0° C.	6·8	..	..	3·98	..	..	..	..	..	..	..
24th March 1928	20·0° C.	7·0	..	..	5·47	..	..	..	..	..	..	..
31st March 1928	19·0° C.	7·1	..	..	5·01	..	..	..	..	..	..	..
2nd June 1928	11·5° C.	6·79	·0003	·0006	..	..	·03	1	·01	50	3	5
30th June 1928	..	..	..	..	..	..	·03	..	..	..	..	..

2. POTCHEFSTROOM LAKE AND HARTEBEESTPOORT DAM, 1928.

Potchefstroom, 25th March 1928	23·5	7·2	·00015	·0058	5·6	..	·02	·5	·015	4	2	5
Hartebeestpoort, 29th April 1928	21·0	7·2	·0002	·0025	..	..	·02	3	·01	10	<1	4

† King and Lucas picrate standard.

Section II.

TECHNIQUE.

The investigation covers a period of two years, the first collection having been made on the 11th of June 1927, and the last on the 15th of June 1929. During the first year weekly collections were taken on a Saturday morning at about 9.15 A.M. (half an hour earlier in summer), and during the second year every fortnight during the first months and once a month during the latter part. The author regrets that these weekly collections could not be continued during the second year owing to difficulties in connection with the work. On a few occasions collections were made on a Friday at the usual time, and once only (2/12/27) was the material collected during the afternoon.

The plankton material was collected between two fixed points (B–C, see map, p. 335). Starting from A (the boat landing), the boat was rowed across to B, when a sample was collected, which was taken back alive in a thermos flask and examined at once as a control. At B, the net was put out and as straight a course as possible made for C, covering an approximate distance of 360 metres; the time taken for this was noted and varied from 10 to 12 minutes. At times it was found necessary to start from the other end (C) on account of a strong wind blowing from that direction. The net pulled at an approximate distance of 16 metres behind the boat and had a pair of wings, as used by learner swimmers, attached to it, thus preventing it from sinking; by this means the net was kept at the same level, directly under the surface of the water to a depth of 39·5 cm. (diameter of net). The net was attached to a rope measuring 16 metres and thus dragged at that distance behind the boat. This technique was necessary to prevent the net dragging on mud banks.

While on the straight course between B and C the temperature of the surface water was taken by immersing the thermometer under water on the shaded side of the boat, and reading the temperature while the thermometer was still under water. A sample of water was also filtered for the purpose of determining its pH value as soon as the laboratory was reached.

On reaching C the net was hauled in and as much water as possible allowed to filter through the net (taking care that the catch was still covered with water); the contents were then carefully transferred to a graduated jar, allowing this to amount to 200 c.c.; 200 c.c. of 4 per cent. formalin were added, yielding 400 c.c. of plankton in a 2 per cent. formalin solution. At the beginning the material was fixed and preserved in 4 per cent. formalin, but this was found to be a rather irritating strength to examine, and subsequently 2 per cent. formalin was used, as described above, which

preserved the material equally well and proved to be a better preservative for phytoplankton.

The type of net used was one of standard size, as used at the Marine Biological Station, Port Erin, Isle of Man, and the silk bolting cloth of the finer quality, No. 20. In June 1928 a new net was put into operation, as by that time the silk of the first net had become badly clogged ; the difference in haul can readily be seen in Graph II. In February 1929 another new net was used, but at that time no difference was observed, as the second net had not been in such frequent use as the first.

The clogging of the net was undoubtedly an important factor affecting the catch during the period February to 16th June 1928 ; unfortunately it was impossible to take weekly samples during that period in 1929, and the March 1929 sample was not available for examination, owing to an accident to the jar.

Counting cells had to be made by having slides ruled in millimetre and ·4 millimetre squares, and then having glass walls glued round the edges, as counting chambers were not available.

As stated before, the standard volume was made up to 400 c.c. ; this was thoroughly mixed and then 10 c.c. taken ; 1 c.c. from this was diluted in 9 c.c. of water and ·025 c.c. or ·05 c.c. of this, according to the nature of the haul, transferred to the ·4 mm. graduated counting chamber and examined under the microscope for the smaller organisms not clearly detectable under a binocular. It was found necessary to take such a small amount in order to see the Melosira strands and other phytoplanktonts clearly. For the larger planktonts, *e.g.* Rotifera and Crustacea, the same procedure was adopted, excepting that 1 c.c. of plankton was diluted in 4 c.c. of water and then ·05 c.c. or ·1 c.c. of this was transferred to the millimetre graduated counting chamber. (This dilution was sometimes also used for the smaller organisms when the plankton was less abundant.) The large Crustacea and Insect Larvae were counted in a 1 c.c. or sometimes even 10 c.c. undiluted sample in a larger graduated cell.

The samples for counting were thoroughly mixed whenever a certain volume was taken. In each case three counts were made and the average figure taken. After recording, these were computed for 1 cubic centimetre.

Many of the less common species were not observed in the counts, but at least three undiluted samples of each collection were always examined to have as complete an account as possible of the various genera and species present in each haul, though the author fully realises that many of the smaller species of phytoplankton (nannoplankton) have probably escaped notice. A richer series of samples could undoubtedly have been collected amongst the reeds and other marginal plant life, but such littoral forms were considered to be outside the scope of the present investigation.

Section III.

OBSERVATION ON SEASONAL SUCCESSION.

PHYTOPLANKTON.

The following genera and species of Phytoplankton were observed. In each case the period of occurrence and maximum, if such occurred, are stated. All the species have been identified by Miss Rich, excepting a few marked by an asterisk, which have been named to the best of my ability on my own authority. In agreement with the actual numbers of various plankton constituents represented in the graphs, the relative abundance of the genera and species is represented approximately as follows :—

1–200	per c.c. . . .	very rare,
200–800	,, ,, . . .	rare,
800–2000	,, ,, . . .	rather rare,
2000–5000	,, ,, . . .	rather common,
5000–50,000	,, ,, . . .	common,
50,000–	,, ,, . . .	very common.

The temperature range and pH variation for the months mentioned under each species can be ascertained from the graphs. Unless specially stated, the periods of time, given below, refer to both years of investigation.

FLAGELLATAE.

Euglena.

Euglena oxyuris Schmarda f. *minor* Déflandre. Very rare, none observed from May to August of either year.

**Euglena acus* Ehrenb. Only seen from March to May 1928, and then the species was very rare.

Lepocinclis.

Lepocinclis texta (Duj.) Lemm. forma and *L. ovum* (Ehrenb.) Lemm. Very rare, none observed from June to August.

Phacus.

Phacus longicauda (Ehrenb.) Duj. var. *torta* Lemm. and *P. pleuronectes* (O.F.M.) Duj. None observed during July ; at other times very rare.

Trachelomonas.

Trachelomonas rugulosa Stein emend. Déflandre and *T. volvocina* Ehrenb. No specimens were observed from May to November ; otherwise present but very rare.

Peridinium.

Peridinium sp.† was found to be perennial and maximal in August 1927 (common), and in September 1928 (rather common). It became very rare from December to May.

CHLOROPHYCEAE.

Chlamydomonas.

Chlamydomonas sp. was occasionally present, but the species could not be determined from the preserved material.

Ankistrodesmus.

Ankistrodesmus falcatus (Corda) Ralfs. Occurred very rarely in August 1927, January 1928, and in April and May 1928.

Coelastrum.

Coelastrum cambricum Arch. var. *intermedium* (Bohlin) G. S. West. Not observed from July to November; very rare at other times.

Coelastrum microporum Naeg. None observed during July; otherwise present but very rare.

Coelastrum reticulatum (Dang.) Senn. None observed from May to July; very rare at other times.

Crucigenia.

Crucigenis tetrapedia (Kirchn.) W. and G. S. West var. *apiculata* Fritsch and Rich. None observed in January and February; otherwise present but very rare.

**Crucugenia quadrata* Morren. Recorded only for June and July 1928, and then it occurred very rarely.

Dictyosphaerium.

Dictyosphaerium pulchellum Wood, and *D. ehrenbergianum* Naeg. The occurrence was very rare, although no specimens were observed from June to August 1928. A small increase was recorded in April 1928.

Gloeocystis.

Gloeocystis ampla Kütz. None observed from June to September, and very rare for the rest of the time.

† Dr. K. Höll, in a paper in the press, identified, in a sample from Florida Lake, *P. bipes* Stein and *P. Volzii* Lemm.

KIRCHNERIELLA.

Kirchneriella obesa (W. West) Schmidle var. *aparta* (Teiling) Brunnth. Attained maxima in September 1927 (rather rare), and in November to December 1928 (rather rare). No specimens were observed during July and August, at other times it was generally very rare.

MOUGEOTIA.

Mougeotia sp. was found to be present in August and October only, and then its occurrence was recorded to be very rare.

SPIROGYRA.

Spirogyra sp. Very rare and present in plankton in October only.

COSMARIUM.

Cosmarium bioculatum Bréb. var. *bians* W. and G. S. West forma. Found to be present only from July to September, and then it was very rare.

CLOSTERIUM.

Closterium sp. Observed only in October 1927 and November 1928, when it was very rare.

DESMIDIUM.

Desmidium baileyi (Ralfs) de Bary var. *coelatum* (Kirchn.) Nordst. Observed only in May 1928, when it occurred very rarely.

SPHAEROZOSMA.

Sphaerozosma granulatum Poyet Biss. Very rare during September and December 1927 and also in December 1928; otherwise the species was not observed.

STAURASTRUM.

Staurastrum dejectum, de Bréb. var. *patens* Nordst forma. Observed only during period December 1927 to May 1928 (very rare), and December 1928 to April 1929 (very rare).

Staurastrum paradoxum Meyen. Yielded small increases in numbers during December 1927, April to May 1928, December 1928 and May 1929, and was found to be very rare at other times.

Staurastrum schuurmani Rich. None noticed during July and August. During other months the species was recorded to be very rare, excepting for a small maximum registered in December 1927.

Staurastrum stephensii Rich. Present only in December and beginning of January (very rare).

Staurastrum subvestitum Rich. None recorded for period March to August; very rare during the other months excepting for a small maximum in December 1927.

Staurastrum volans W. and G. S. West. Recorded only in November and January.

LAGERHEIMIA.

**Lagerheimia longiseta* (Lemm.) Printz. var. *major* G. M. Smith. Occurred in March 1928 (very rare).

MICRACTINIUM.

**Micractinium* sp. was observed only in September and October 1927, when it was very rare.

OOCYSTIS.

Oocystis sp. None noticed from July to October; very rare at other times.

PEDIASTRUM.

Pediastrum duplex Meyen and *P. duplex* Meyen var. *clathratum* A. Br. Perennial and always very rare, with a slight increase to rare in October.

Pediastrum tetras (Ehrenb.) Ralfs. Observed only in June 1928 (very rare); the species may have been overlooked at other times.

SCENEDESMUS.

Scenedesmus quadricauda (Turp.) de Bréb. var. *parvus* G. M. Smith. None observed in August; otherwise very rare.

Scenedesmus bijugatus (Turp.) Kütz and *S. acuminatus* (Lagerh.). Chodat have also been observed occasionally.

SPHAEROCYSTIS.

Sphaerocystis schroeteri Chodat. Very rare, though small increases were registered for the periods September 1927 to March 1928 and November 1928 to February 1929. No specimens were noticed in July and August.

HETEROKONTAE.

BOTRYOCOCCUS.

Botryococcus protuberans W. and G. S. West was found to occur very sparingly throughout the time of investigation.

BACILLARIACEAE.

Achnantes.

Achnantes sp. was observed only in August 1927, when the species was very rare.

Gomphonema.

Gomphonema sp. Occurred very rarely from October to February.

Melosira.

Melosira ambigua (Grün) Müller subsp. *variata* was found to occur throughout the time of investigation and yielded maxima in June 1927 (very common), October 1927 (very common), June–July 1928 (common), and May–June 1929 (very common). Auxospore formation was observed in January and February.

Tabellaria.

Tabellaria flocculosa (Roth) Kütz. None observed from January to March; otherwise its occurrence was very rare, though a slight increase appears to occur around June to August.

Occasional individuals of *Navicula* sp. and other diatoms have been observed at various times, but their occurrence seemed too rare and occasional to be worth placing on record.

MYXOPHYCEAE.

Anabaena.

Anabaena affinis Lemm. f. *minor*. None observed from March to August; very rare for rest of time, excepting for a slight increase in December 1927.

Aphanocapsa.

Aphanocapsa elachista var. *conferta* W. and G. S. West. Very rare, with a slight increase from the end of December to January. None observed in May.

Aphanocapsa elachista var. *planktonica* G. M. Smith has been observed in January only (very rare).

Chroococcus.

**Chroococcus minutus* (Ktz.) Naeg. Very rare; none seen from April to September.

LYNGBYA.

Lyngbya sp. Observed in December and January only, when the species occurred very sparingly.

MICROCYSTIS.

Microcystis flos-aquae (Wittr.) Kirchn. Perennial; usually very rare to rare. The species was most abundant in November 1927 (rather common) and February 1929 (rather rare).

OSCILLATORIA.

Oscillatoria sp. Observed in July only.

CHRYSOPHYCEAE.†

DINOBRYON.

Dinobryon divergens Imhof appeared suddenly on the 3rd September 1927 (4400 per c.c.), and was present in every collection taken after this date, while the week before none had been observed. Maxima have been registered for September 1927 (common) and July 1928 (very common). During the intervening period the occurrence varied from very rare (December 1927 to May 1928) to common; during November–December 1928 the occurrence was again found to be very rare, while in May and June 1929 the species was found to be common.

MALLOMONAS.

Mallomonas producta (Zach.) Iwanoff var. *marchica* Lemm. Appeared to be perennial, though it occurred rather sparingly. The species yielded a maximum in October 1927 (common); it was very rare from November 1927 till February 1928; rare from March 1928 till May 1928; very rare from June 1928 till June 1929.

ZOOPLANKTON.

PROTOZOA.

The following Protozoa were observed in the material and have been identified to the best of my ability:—

FORAMINIFERA.

DIFFLUGIA.

Difflugia oviformis Cash was present in varying numbers in every collection, and yielded maxima in October 1927 (common) and November 1928 (rare).

† Pascher, 1914, p. 143.

HELIOZOA.

Actinosphaerium.

?*Actinosphaerium* was found in every collection from 10th September 1927 when it was rather common, while the maximum was attained on the 30th (common); for the rest of the time its abundance varied between rare and very rare.

ROTATORIA.

The relative abundance of the genera and species is represented approximately as :

1–50	per c.c.	.	.	very rare,
50–200	,, ,,	.	.	rare,
200–500	,, ,,	.	.	rather rare,
500–1000	,, ,,	.	.	rather common,
1000–2000	,, ,,	.	.	common,
2000–	,, ,,	.	.	very common.

Synchaeta.

Synchaeta pectinata Ehrenberg. Possibly perennial, although not observed in April and May 1928, when the net was badly clogged. Maxima were attained in September 1927 (rather common) and 1928 (rather rare), while the occurrence at other times was rather sparing.

Polyarthra.

Polyarthra trigla Ehrenberg was not observed during July and August; its occurrence was very rare, excepting for a week in October and in December 1927, when the species was found to be rare.

Trichocerca.

Trichocerca chattoni (de Beauchamp) was observed only from October to February when it was usually very rare, excepting on the 17th December 1927 and 19th December 1928, when small maxima were registered (rare).

Asplanchna.

Asplanchna brightwellii Gosse was present only from October till February, and then it was very rare.

Brachionus.

Brachionus angularis Gosse was not observed during April and May;

maxima were attained in August 1927 (very common) and October 1928 (rather rare).

Brachionus calyciflorus dorcas Gosse was present (very rare) from June to March only.

Brachionus calyciflorus spinosus. Perennial, usually very rare. Maxima were attained in October 1927 (rather rare) and November 1928 (rare).

Brachionus falcatus Zacharias. Not observed from July to September; maxima were registered in December 1927 (common), and December and February 1928 (common).

KERATELLA.

Keratella cochlearis Gosse was present in varying amounts in every collection. Several small maxima were registered from June to December, the chief maxima falling in October 1927 (very common), and 1928 (very common). Very rare during January to April.

Keratella quadrata valga (Ehrenberg) was found to be perennial; several small maxima were observed between June and November, the chief maxima were registered in August 1927 (rather common), and September 1928 (rather common). Very rare during December to February.

ANURAEOPSIS.

Anuraeopsis fissa (Gosse) was observed only during June, July, and August, when its occurrence was very rare.

TETRAMASTIX.

Tetramastix opoliensis Zacharias was recorded only from October till May. The maximum was attained in January 1928 (common) and would possibly have occurred in the same month in 1929 had a record been available, as a decided increase is seen in February 1929.

PEDALIA.

Pedalia mira (Hudson) was noted only during the period October till June; the maximum number was recorded for 26th November 1927 (rather rare) and again towards the end of November 1928. The species was never very abundant.

POMPHOLYX.

Pompholyx sulcata Hudson. Possibly perennial though never common. Small maxima occurred in November 1927 (rather rare), and February 1929 (rather rare).

Conochiloides.

Conochiloides dossuarius (Hudson). Observed from October till June usually very rare. Maxima were registered in November 1927 (rather rare) and 1928 (rare).

CLADOCERA.

A few species have been identified by Dr. O. Herr; the rest, still awaiting identification, have been named provisionally by the author, and, as in the preceding cases, have been marked by an asterisk.

Chydorus.

Chydorus sphaericus O. F. Müller has been recorded for the 6th August 1927 (very rare), but has not been observed at other times.

Bosmina.

Bosmina longirostris pellucida Stingelin was also identified from the 6th August 1927 sample. Owing to the seasonal variation of this species, monthly samples were forwarded to a specialist for a comprehensive record, but these are still awaiting identification. In the meantime this identification has been used throughout the time of observation. The contour of the specimens appeared to be slightly more rounded in January 1928 and still more in March 1928. The species appeared to be perennial, although occasionally absent from a collection, and was never abundant; a maximum was registered in August 1927 (rather common). Eggs and embryos were observed in the brood-pouch from June 1927 till January 1928, and again in June 1929.

Ceriodaphnia.

**Ceriodaphnia dubia* Richard was observed from June 1927 until May 1928, and again from February 1929 until June 1929, and yielded maxima in July and August 1927 (common). The species occurred in much smaller numbers during the second period than the first. Eggs and embryos were noted in the broodpouch from June till end of August 1927 and again from the middle of September 1927 until middle of February 1928; these were again observed towards the end of March 1928 and from February 1929 until April 1929. Ephippia were seen on the following dates: 25th June 1927, 26th Nov. 1927, 2nd Dec. 1927, 10th Dec. 1927, 18th May 1929, and 15th June 1929.

Daphnia.

**Daphnia longispina* (O. F. M.). Occurred in the samples from August until November 1927 and again from March 1928 until April 1929 ; maxima were obtained in October 1927 (rather common) and August 1928 (rather rare). Eggs and embryos were observed from August till November 1927, March to December 1928, and again in March 1929. Ephippia were noted on 8th October 1927 and 3rd November 1928.

COPEPODA.

Mesocyclops.

Mesocyclops macracanthus Kiefer was present in every collection in varying numbers. Several small maxima were noted during June to October 1927 and 1928, as well as in January 1928 (always rather rare), while on the 3rd November 1928 the species was found to be rather common. Eggs were found to be present throughout the time of investigation.

Paradiaptomus.

Owing to the relative scarcity of this genus its relative abundance is represented as :

1–5	per c.c.	. . .	rare,
5–10	,, ,,	. . .	rather rare,
10–	,, ,,	. . .	rather common.

Paradiaptomus colonialis Douwe was found to be perennial ; maxima were attained in October 1927 (rather rare), June 1928 (rather common), and February to May 1929 (rather common). Eggs were observed from June to December 1927, from March to August 1928, and again from February to June 1929.

No definite study was made of the following species, as these were observed only occasionally in the counts :—

HYDRACARINA.

Piona coccinea (C. L. Koch) was observed in June, July, September, and October 1927.

INSECT LARVAE.

Chaoborus sp. was observed from October 1927 to February 1928, June 1928 (new net) to November 1928, and in February 1929.

Section IV.

VERTICAL MIGRATION.

An attempt was made to obtain some information in connection with the diurnal migration of the plankton at the surface of Florida Lake. Material was collected at three-hourly intervals on 15th to 16th June 1928 (winter) by the method described above. The investigation therefore indicates what organisms entered or left the surface layer during the period studied.

The highest temperature (12° C.) as well as the highest pH concentration (6·79) was registered at 6.55 P.M.; the lowest temperature (10·5° C.) was taken at 3.10 A.M. and 6.5 A.M., whereas the lowest pH concentration (6·59) was obtained from the 12 o'clock (noon) sample.

The actual numbers of 16 organisms have been recorded (Table II); of these, 7 were maximal at 6.55 P.M., and in general a marked concentration of organisms, in which *Melosira* and *Dinobryon* constitute the greatest bulk, was observed at that time.

Table II.

Actual Numbers of various Plankton Constituents per c.c. Three-hourly Observation, 15th to 16th June 1928.

	15th June.		16th June.					
Time	6.55 P.M.	9.7 P.M.	12.5 mid-night	3.10 A.M.	6.5 A.M.	9.15 A.M.	12 noon	3 P.M.
Temp. °C.	12	11·5	11	10·5	10·5	11	11·5	11·5
pH	6·79	6·75	6·75	6·66	6·62	6·62	6·59	6·66
Turbidity cms.	26	25·5	24·5	28	40	shade 48 sun 52	53 58	53 58
Peridinium sp.	390	400	550	650	640	330	430	570
Botryococcus protuberans	p †	p	20	p	..	p	..	30
Melosira ambigua	60200	59150	72650	66050	62900	30950	37350	24000
Tabellaria flocculosa	300	20	p	p	p	20	10	30
Microcystis flos-aquae	p	p	p	p	p	60	60	p
Dinobryon divergens	65750	33250	24750	27100	24800	17850	19400	20300
Difflugia oviformis	..	..	..	..	..	1	..	..
Keratella cochlearis	p	10	50	90	80	20	40	20
Keratella quadrata valga	130	100	180	130	230	220	360	200
Conochiloides dossuarius	10	10	10	p	p	20	40	20
Bosmina longirostris	..	..	..	..	4	..	..	..
Daphnia longispina	610	270	280	300	320	360	540	210
Mesocyclops macracanthus	200	75	45	40	50	50	30	30
Paradiaptomus colonialis	32	13	14	17	11	12	9	8
Nauplii	220	80	120	180	230	210	200	180
Larvae of *Chaoborus* sp. per 10 c.c.	45	14	14	16	8	..	1	1

† p = present.

Peridinium sp., rare at this season, yielded a maximum at 3.10 A.M., the minimum number being recorded at 9.15 A.M.

Botryococcus protuberans, very rare at this particular time, attained a small maximum at 3 P.M.

Melosira ambigua, common at this time, reached its maximum at 12.5 A.M. (midnight), the minimum being registered at 3 P.M.

Tabellaria flocculosa (very rare) yielded a marked maximum at 6.55 P.M.

Microcystis flos-aquae (very rare) was observed only at 9.15 A.M. and 12 (noon).

Dinobryon divergens, common at this particular time, was maximal at 6.55 P.M. and minimal at 9.15 A.M.

Difflugia oviformis (very rare) was observed only in the 9.15 A.M. sample.

Keratella cochlearis (very rare) yielded a small maximum at 3.10 A.M., and a minimum at 6.55 P.M.

K. quadrata valga (rare) was maximal at 12 (noon), the minimum being registered at 9.7 P.M.

Conochiloides dossuarius (very rare) yielded a few more specimens at 12 (noon) than at other times.

Bosmina longirostris, not observed in the usual collection (9.15 A.M.) at this particular time, was present in the 6.5 A.M. collection.

? *Daphnia longispina* (rather rare), *Mesocyclops macracanthus* (rare) and *Paradiaptomus colonialis* (rather common), attained their maxima at 6.55 P.M. *Daphnia* yielded another maximum at 12 (noon).

The Nauplii, taken collectively, yielded two maxima, one at 6.55 P.M. and another at 6.5 A.M.

The larvae of *Chaoborus* sp. were maximal at 6.55 P.M.

The marked concentration of organisms at twilight at the surface observed by Ziegelmeyer (1927) in the Tegeler See has, therefore, been noted at Florida at 6.55 P.M., practically two hours after sunset.

The movement of the larvae of *Chaoborus* sp. is the most definite migration that has been observed. The larvae attained a maximum at 6.55 P.M., very few being present during daytime; this agrees with Juday's work on *Corethra* (*Chaoborus*) sp. in the Wisconsin Lakes. He states that by day this species may occur in the almost oxygen-free region under the thermocline in eutrophic lakes.

The vertical migration of the crustacean fauna of Florida Lake, while less marked in so shallow a lake, appears to agree in general with that observed by Kikuchi (1927) at Kizaki Lake, Japan. Kikuchi found that the maxima of abundance for nauplii, *Bosminopsis*, *Cyclops*, and *Diaptomus* occurred a few hours after sunset in the Kizaki Lake in August (summer).

At Florida Lake (June, winter) this was also observed, but with the exception of *Bosmina* which was noticed only in the 6.5 A.M. sample, thus giving evidence that it comes up to the surface at dawn. *Paradiaptomus* yielded two maxima at Florida Lake, one at 6.55 P.M. and the other at 3.10 A.M., whereas Kikuchi found that *Diaptomus* had only one maximum. It has been stated that in general vertical migration concerns the crustacean members of the plankton primarily. Since it has been found (Kikuchi) that some specimens descend at night, it is probable that the downward migration by day is directed by light, the upward movement by night being merely a re-colonisation by casual wandering of vacated water.

Kikuchi further states that the diurnal migration of diatoms, flagellates, Protozoa, Rotatoria, and other organisms which have very weak locomotor activity has been observed, but the extent of the movement is confined within narrow limits. At Florida Lake it was found that these showed fairly active movement, which was perhaps due to convection currents.

Section V.

CYCLOMORPHOSIS AND PRODUCTION OF EPHIPPIA.

Cyclomorphosis refers to a periodic change in form undergone by certain species of planktonic organisms. The most striking case is found in certain species of *Daphnia* (*D. longispina*, *D. cucullata*, etc.), in which the head develops an enormous projection in front during the summer in some localities. The process generally affects spines and similar projections, and is seen in Dinoflagellates (*Ceratium* spp.) and Rotifers as well as in Cladocera. In general it is probably best developed in localities where there is a very wide range of temperature in passing from winter to summer, as for instance in Central Europe, where the lakes freeze in winter and may be quite warm in summer (up to 30° C.). Usually the forms with long spines and projections occur in the summer, but in some cases the reverse is true (*Ceratium*).

In Florida Lake such variations are at a minimum, as there is no wide range of temperature. The following small differences were observed during the period of investigation. *Polyarthra trigla* was observed to be producing eggs during February–March and in March larger individuals were also noticed ; these produced no eggs. Virieux (1916) states that in the Jura Lakes the female individuals of this species pass the winter as young, grow to full size in spring, and reproduce till two types appear in the summer broods, namely, small precocious females which lay eggs early, and large

forms which are the full-grown type. In the autumn only small individuals survive the cold weather and then grow to the intermediate size in spring. The large form occurs only in the small lakes and is dark brown in colour. In Florida Lake the small winter forms were possibly overlooked; egg-production is also late (February and March, *i.e.* late summer), and the large individuals were noticed in March, April, May, and June; in September and October the smaller individuals were again observed. The difference in size was not very striking, and was at first taken to be differences in growth. The cycle, though probably based on inadequate evidence, is of great interest. Larger individuals of *Brachionus angularis* or *B. falcatus* were not observed in summer in Florida Lake.

The seasonal occurrence of Cladocera appears to be very variable; *Bosmina* appears to be perennial and possibly has a sexual period extending over the period June–January, when it occurred in Florida Lake. *Ceriodaphnia* was reproducing asexually practically throughout the time it was present, as eggs and embryos were found; ephippia were observed in June and November–December 1927, and again in May–June 1929.

Daphnia behaved in a rather different way; eggs and embryos were present during August–November 1927, and March–December 1928, while ephippia were observed in October 1927 and November 1928. *Daphnia*, therefore, appears to be monocyclic, producing ephippia only in spring.

Ceriodaphnia and *Daphnia* both continued to be present after ephippia were produced.

Section VI.

DISCUSSION.

A comparison on the observations at Florida Lake with those of other localities is here given, but it must be borne in mind that most of the European and North American localities are not strictly comparable as the water gets too cold in those regions in winter (below 4° C.). At Florida Lake the lowest temperature registered was 7·5° C. and the water never freezes. The resemblances are of course worth noting.

The **Flagellatae** appear to be absent from the Florida Lake plankton during the winter months (June–August); Kofoid also found these to be more abundant during the summer months in the Illinois River.

The **Protococcales** appear to be absent during the winter months from the Florida Lake plankton, as in most cases none were observed during July–August. Brutschy (? 1916) found that *Dictyosphaerium pulchellum* occurred during June–August in the Hallwiler See. At Florida Lake none were observed during August, while a slight increase in numbers

was noted in April. Wesenberg-Lund states that *Pediastrum* is not really limnetic and yields no special maximum, but the data obtained from Australia (West, 1909), Ceylon (Apstein, 1907), California (Scott, 1927), and the Hallwiler See (Brutschy ? 1916) suggest that the genus yields a summer maximum, at least in tychoplankton. At Florida Lake *Pediastrum duplex* and its var. *clathratum* yielded a possible maximum in October (*i.e.* spring) ; *P. tetras* was observed only in June, but may have been present at other times ; Scott found it to be maximal in July in California. *Scenedesmus quadricauda* yielded no maximum at Florida Lake and no specimens were observed during August. In the Hallwiler See, Brutschy found it to be marginal from May–October ; Kofoid (1908) found the species to be perennial in Illinois River, though it occurred less frequently from November–April. In Belgian Congo the species is recorded by Van Oye (1927) in March and May.

In general the few species under consideration compare well with observations in the Northern Hemisphere.

No definite maximum can be recorded for *Botryococcus protuberans* ; it was observed to be perennial and no colour changes were noted.

Melosira ambigua, perennial at Florida Lake and fairly common, was maximal from May–July (*c.* 14°–7·5° C.) and also in October (16° C.), *i.e.* winter and spring. This fully agrees with Virieux's observations on the Jura Lakes (November–May) and Wesenberg-Lund's on the Danish Lakes (winter, 4·6° C.), though the latter observations were based on *M. crenulata*. In general diatoms reach a maximum in spring, and in this respect the Florida Lake is in agreement with previously investigated localities. It is striking to note that *Melosira granulata*, the chief diatom of tropical and subtropical lakes (West, Apstein) is not recorded from Florida Lake. The relative scarcity of *Melosira* during the period February–May 1928 must be attributed to the use of a poorly functioning net ; this also applies to the scarcity of *Microcystis*. The comparative paucity of diatoms and the absence of some of the widely distributed plankton genera is probably due to the relatively high temperature of the water ; usually diatoms attain their maximum development at a temperature of 5°–7° C. in Europe.

As a rule the **blue-green algae** have their maxima in summer and only then exist in really great quantity, but some species, e.g. *Oscillatoria rubescens* (Virieux, 1916), have a very striking spring maximum ; according to Wesenberg-Lund this is the only blue-green characteristic of very large deep lakes in Europe. Other species, such as *Chroococcus limnetica*, *Lyngbya bipunctata* and some *Aphanizomenon* spp. may have a winter maximum (2°–5° C., December–April). The few representatives of this class at Florida Lake apparently have their maxima during November–February, *i.e.* summer, except *Oscillatoria* sp., which was only observed

in July. *Microcystis flos-aquae*, rather rare on the whole, was observed to be perennial. Virieux observed a maximum of *M. aeruginosa* and *M. flos-aquae* in Jura Lakes during August–November, and other species, as observed by various other authors, were maximal during April–September. Kofoid (1908) found *M. ichthyoblabe* to be perennial in the Illinois River, yielding a minimum during the cold months (November–April) and a maximum during August–October. Chroococcus and Lyngbya were not observed during April–September, and therefore could not have yielded a winter maxima at Florida Lake. *Anabaena affinis*, yielding a slight increase in December at Florida Lake, presents the same seasonal maximum as its allied species at California (Scott, 1927) (July), Danish Lakes (Wesenberg-Lund) (August), Colombo (Apstein, 1907) (July), England (Hodgetts) (summer), and Poland (Wislouch) (August).

Huber-Pestalozzi (1925) in a short note indicates *Microcystis aeruginosa* and *Melosira* as common South African forms ; *Melosira* is certainly a dominant form at Florida Lake, though *Microcystis* can only be regarded as subdominant ; while *Dinobryon* can be regarded as another dominant. *Melosira* and *Microcystis* are the dominant algae of the lake of Colombo.

Numerous blue-green algae have been listed by West from Tanganyika ; it is probable that an abundance of Myxophyceae, especially those having a summer maximum in Europe, is characteristic of tropical or subtropical countries. In contrast to this, these algae are rare in the lakes of the arctic or subarctic regions, *e.g.* Iceland (Ostenfeld and Wesenburg-Lund (1905)). It cannot be said that the blue-greens are very abundant at Florida Lake, and it is probable that the chemical composition of the water has a direct influence on the growth of blue-green algae.

The **Chrysophyceae** of Florida Lake appear to have their maxima during July–October, *i.e.* winter and spring, and to be perennial. Haempel (1925) observed *Dinobryon divergens* in the Attersee in May and October. Gran and Ruud (1927) in Hurdals See during August–October ; at Florida Lake it attained a grand maximum in September 1927 and July 1928, and was possibly also common in May. The occurrence of *Dinobryon* only in the warmer part of the year (18°–20° C.) in the Yan Yean Reservoir calls for special attention ; in the British Lakes this genus reaches its maximum in spring, according to West at a temperature below 15° C. This agrees with Tanner-Fulleman's observations on the maximum development of *Dinobryon* in certain Swiss Alpine lakes at a water temperature of 11° C. At Florida Lake the maxima were registered at 9·5° and 15·5° C. In the lakes of tropical Africa, having a mean temperature over 20° C., *Dinobryon* is entirely absent. *Dinobryon* affords an interesting example of sudden appearance, having been absent for the period June–August 1927, and common and very common during that period in 1928.

Mallomonas producta is possibly maximal in October at Florida Lake, *i.e.* spring. Virieux (1916) also found a spring maximum to occur in the Jura Lakes.

Schreyer states that *Synchaeta oblonga*, a winter species (October–June), increases with the increase of *Dinobryon sertularia*; the maxima clearly depend on which species is present. At Florida Lake *Synchaeta pectinata* was found to be perennial, having its maximum on the 24th September 1927, while *Dinobryon divergens* was maximal on the 10th September 1927. In 1928 the maximum for *Synchaeta* was registered on the 15th September, while *Dinobryon* yielded a maximum on the 7th of July.

The **Protozoa** appear to be more abundant during July–November, and less abundant during December–June. *Difflugia oviformis* was observed to be maximal in October and November at a temperature of 17°–19° C. Wesenberg-Lund records *Difflugia hydrostatica* to be maximal between May and August in the Danish Lakes; Virieux (1916) from June to October in the Jura Lakes, and Brutschy (?1916) in July in the Hallwiler See. Scott (1927) found *D. pyriformis* and *D. urceolata* to occur in California from May to June. While there is great uncertainty as to the taxonomy of planktonic species of *Difflugia*, there seems to be little doubt that in the temperate part of the Northern Hemisphere they all have summer maxima and perhaps only come up to the surface at that time.

Wesenberg-Lund considers that the majority of rotifers are either monocyclic with one maximum at the height of summer, or dicyclic with two maxima in spring and autumn respectively; the sexual periods occur, if at all, at the ends of the maxima. Also, the maxima are more clearly marked in ponds than in lakes where the sexual periods may be suppressed. The sexual periods were not investigated in Florida Lake.

Synchaeta pectinata appears generally to be considered as a winter form. Schörler, Thallwitz, and Schiller (1906) consider this species to be a cold-water form, absent from June to October, and having a maximum from April to May in Dresden. Virieux (1916) records a winter maximum for the Jura Lakes, while Schreyer states that in large lakes it is a cold-water dicyclic form with maxima in November and March; in smaller waters it is perennial with maxima irregularly between June and October, when it is rare or absent from large lakes. The species in limno-plankton is evidently generally a winter form. In Florida Lake *Synchaeta pectinata* appears to be perennial, having a maximum in September, *i.e.* spring. Kofoid also found this species to be perennial in the Illinois River, the greater proportion occurring between May and October.

Polyarthra trigla is considered to have one or more maxima in the warmer seasons in temperate waters. In the Alpine Lakes, Haempel (1923) gives a June–July or sometimes an October maximum. Kuhl (1928)

registers a July–August maximum with or without a spring maximum in Upper Bavaria. Shörler, Thallwitz, and Schiller (1906) refer to irregular maxima during March, April, May, and August, with a minimum in June and December–January in Dresden. Watzka (1928) found the species to be maximal in March, having a subsidiary maximum in June, while it was minimal in November, in a pond in Poland. In the Jura Lakes it is stated to be present during the warmer parts of spring and autumn by Virieux (1916). In a permanent pool in Palestine Krampner (1928) found it from April to June and maximal in April and May. Apstein (1907) records it to be present only in June (maximum) and September in Ceylon. Kofoid (1908) found *P. platyptera* to be perennial in the Illinois River and to be more abundant during the warmer months. None were observed during July–August (*i.e.* winter) in Florida Lake, and no marked maxima have been observed.

Asplanchna brightwellii was observed only during October–February in Florida Lake (*i.e.* spring and summer). In Ceylon Apstein (1907) found it to have irregular maxima in July and January (dry season), while at Florida Lake it is present during the rainy season. In a temporary pond in Palestine Krampner (1928) found it to occur from February to March, *i.e.* as the pond was drying up at the end of the rainy season. In Dresden the species was observed in April and July only, while in Poland a March maximum, a subsidiary June maximum and a minimum in December have been registered. Kofoid (1908) records *A. brightwellii* as a polycyclic perennial plankton, being more abundant between May and October in the Illinois River.

Brachionus angularis, tychoplanktonic according to Schreyer, was maximal in July, August–September, and November and May in Switzerland. None were observed during April–May, while maxima were registered in August and October, during the period of investigation at Florida Lake. This species was much more abundant during the period June–September 1927 than in the same period in 1928 at Florida Lake. In the Illinois River it was found to be perennial, more abundant from May to November.

Brachionus calyciflorus dorcas, perennial in Florida Lake, having maxima in October and November, was found to have June–July, September, and October maxima in Switzerland by Schreyer. *B. calyciflorus pala* is stated to be perennial in Switzerland by Schreyer, while in Poland Watzka (1928) records a June maximum and a November minimum. In Palestine the species occurred from April to July with a maximum in April. Apstein (1907) found the species in Ceylon having a July maximum, as well as in September.

Brachionus falcatus, maximal in December–February in Florida Lake, at a temperature of 21°–22° C., was not observed during July–September. Apstein has recorded the species from the Lake of Colombo, Ceylon, and

found it to be present during May–June and later July–September, being maximal in August.

Keratella cochlearis, perennial in Florida Lake, yielded several small maxima from June–December, the chief maximum occurring in October (*i.e.* winter and spring). This species may undergo marked cyclomorphosis, especially in small bodies of water; no appreciable change was noted during the period of investigation at Florida Lake. Jennings, in Lakes Michigan and Erie and inland waters of Michigan, records the species as a summer plankton, while Zimmer, in the River Oder, states that it is the most common winter form. Kofoid also found the species to be perennial in the Illinois River, having an optimum probably at temperatures somewhat below the maximum, between 60°–70° F. Birge states that in thermally stratified lakes in Wisconsin this species is found above the thermocline, while *K. quadrata* is found in the deeper cold water below. In Belgian Congo (van Oye, 1926) the species was maximal in February, March, and April. In Florida Lake *Keratella cochlearis* was more abundant during June 1929 than June 1928.

Keratella quadrata valga, also perennial in Florida Lake, and having several small maxima from June to November (grand maximum in August and September), was found to have March–May and September–October maxima in Palestine by Krampner (1928). *K. quadrata* var. *tropica*, which appears to be definitely associated with the warmer parts of the world and to which the *K. quadrata* of Florida Lake bears a great resemblance, had a July maximum (dry season) in the Lake of Colombo (Ceylon).

Pedalia mira appears to be a summer form in Florida Lake, as it was observed from October to June, yielding a maximum in November. Schreyer also found it to be a summer form in small lakes and ponds in Bern district (Switzerland). Krampner (1928) records a May maximum in a permanent pool in Palestine, while in the Lake of Colombo, Apstein records irregular maxima in June for the dates examined (May–September). Kofoid mentions the species as a summer plankton from the Illinois River.

Anuraeopsis fissa, observed only during June–August (winter) in Florida Lake, was very rare at the time. Dieffenbach (Die Süsswasserfauna Deutschlands) mentions *A. hypelasma* as a summer form.

A comparison with Rousselet's list of Rotifera from South Africa (1906) reveals the fact that many species present in the Transvaal were not observed at the time of Rousselet's visit, August–September, when the country had not yet been favoured with summer rains and many small streams and dams were still dry. Rousselet comments on the total absence of such a prominent group as *Asplanchna*; it is not surprising to find that none were collected as this genus was observed in Florida Lake only during October–February. *Polyarthra* was also not observed in the Transvaal;

the Florida collection yielded no specimens during July–August. *Brachionus angularis* was observed to be common during June–September 1927, while very rare during June-September 1928 in Florida Lake ; this variation in seasonal succession probably accounts for the omission from the Transvaal in Rousselet's list of such species as *B. angularis*, *B. pala* var. *dorcas*, *K. cochlearis*, and *K. quadrata valga*. It is not surprising to find that *Pedalia mira* was not collected in the Transvaal, as this species was only observed from October to June in Florida Lake. This species as well as *Pompholyx complanata*, *Conochiloides dossuarius*, and *Tetramastic opoliensis* have been listed (Rousselet) from Rhodesia and not from the Transvaal, although these (*Pompholyx sulcata* from June) have been observed in Florida Lake from October. The higher temperature experienced in Rhodesia may account for this. It is notable, however, that *Brachionus falcatus*, a common species in the Transvaal, was not observed by Rousselet either in the Transvaal or Rhodesia, though none were observed during July–September in Florida Lake. *Trichocerca* was also only observed during October–February in Florida Lake.

Trichocerca chattoni and *Asplanchna brightwellii*, which have been observed from other localities in South Africa, appear to be summer forms, while *Brachionus falcatus* and *Tetramastix opoliensis* are almost certainly warm-water species, being common in Central Africa and rare in Europe. *Tetramastix*, according to Bryce (*in litt.*), is still a remarkably rare species, and Rousselet found only three specimens near Rhodes's Grave, Rhodesia. Zacharias (1898) found this species in plankton from near Oppeln. Further records of these species are given by Hutchison, Pickford, and Schuurman (*in press*) ; in addition to the localities given in their paper, *T. chattoni* has been taken in a sample from Sandown, Johannesburg, in March 1929, *B. falcatus* from a dam on the Geldenhuis estate, Johannesburg (16th December 1930), and *T. opoliensis* from the latter locality and from Vereeniging Barrage (3rd August 1928).

Birge (1897) classifies the Crustacea of Lake Mendota into *periodic*, only found during a definite and limited season of the year, and *perennial*, found at all times of the year, though usually fluctuating in numbers. In the Northern Temperature Zone the most important periodic forms are certain species found in the plankton of large lakes, having their maxima at the end of summer and being entirely absent in the latter part of winter and early spring.

The Cladocera of Florida Lake appear to be very erratic in their sequence during the two years of investigation. *Ceriodaphnia* appears to be perennial during the first year, and yet during the second year it is present for only five months. *Daphnia*, on the other hand, was present for the period March 1928 to April 1929, while only from August to November in 1927.

Daphnia hyalina (including *D. longispina*) is stated by Birge (Trans. Wisc. Acad., 1897) to be perennial, having three maxima—May–June, June–July, or August and October; the extreme minimum occurs in January–March; while summer maxima, as described in such detail by Birge (1897) occur in many localities, this species apparently may reach the height of its development almost any time, save at the extreme end of winter and beginning of spring. Kofoid in his report on the Illinois River, states that *D. hyalina* is a variable species, occurring mostly above 70° F.; also, that there is no apparent cause for its absence. In Florida Lake *D. longispina* was maximal in October and August (*i.e.* end of winter and spring). *Ceriodaphnia* was maximal during the first period of its occurrence in Florida Lake in July (winter). Kofoid states that temperature rather than season is a dominant factor in the seasonal curve of *Ceriodaphnia*; the species does not advance rapidly in its sexual increase until after the water warms to 70° F., and drops suddenly in numbers when the autumnal decline passes this point; the maximum was registered for May–June. *Ceriodaphnia pulchella* is stated by Pasquini (1924) to be tychic and was found to have an August maximum, and to be absent during November–April and June in Lake Trasimere (Italy).

Chydorous sphaericus has been recorded by Dr. O. Herr for August from Florida Lake, but the species has not been observed at other times. Birge (1897) states that this species is found primarily in shallow water and feeds on *Anabaena*; it is therefore characteristic of lakes with much Myxophyceae, which may account for its rarity in Florida Lake.

Bosmina longirostris, perennial in Florida Lake, maximal in August 1927 and yielding no maximum in 1928, has been observed in Dresden by Schörler, Thallwitz, and Schiller (1906) as having a maximum in April–May and as being absent in July–August. Kofoid (1908) found the species to be perennial in the Illinois River, occurring in small numbers during January-March, and yielding a maximal development at the end of May (or beginning of June); in October there was a decline in amplitude and in November and December they often failed to appear in the small numbers recorded. Females with eggs or embryos were present at all seasons of the year and at all temperatures.

The seasonal succession of the Cladocera found in Florida Lake does not appear to be constant and is probably influenced by other factors than seasonal changes. *Bosmina* was found to be rather common during June–August 1927 (new net) and absent during the same period in 1928, although a new net was used. *Ceriodaphnia*, common and rather common from June to August 1927, was absent during that period in the ensuing year; *Daphnia* was not observed in June and July 1927, while it was rather rare during those months in 1928.

It is not to be expected that the seasonal variation should be entirely constant, but such inconsistency as has been indicated above clearly shows that this may vary during successive years, and an investigation carried over a longer period than two years is necessary before definite conclusions can be drawn. Incidentally it may be remarked that at the Barrage, Vereeniging, from whence the Johannesburg water supply comes, it has been observed that these organisms may be plentiful during a certain period and absent during the same period in another year.

Owing to the large number of species of restricted range it is impossible to provide data of direct value for making a comparison between the Copepoda from Northern and Southern Hemispheres. Different species of the Cyclopoids have their maxima at very different seasons, though some species may usually be found throughout the year. Thus *Cyclops strenuus* in temperate Europe has a winter maximum, while *C. leuckarti*, which often occurs in the same lakes, is most abundant in summer (Schörler, Thallwitz, Schiller, 1906). In the Lake of Colombo, *Cyclops leuckarti* is most abundant in the " winter " dry season during January (Apstein, 1907). At Florida Lake *Mesocyclops macracanthus* was found to be perennial, and several subsidiary maxima occurred from June to October and in November and January. Reproduction was found to take place throughout the year.

In temperate Europe and North America the various species of *Diaptomidae* seem usually to have summer maxima. In the Lake of Colombo Apstein found *Diaptomus annae* to be most abundant in the " summer " dry season (July). In both temporary and permanent waters in Palestine, in which the temperature never sank below 9·5° C., Krampner (1928) found *D. similis* to be most abundant in February and March during and just after the coolest weather. In South Africa *Paradiaptomus colonialis* was found to be perennial and to be maximal in October (subsidiary), June, and February. It must be stated that the seasonal variation does not appear to be constant ; in June 1927, when a new net was used, only 3 per c.c. were recorded, while in June 1928 (new net) there were 12 per c.c. In October 1927 a subsidiary maximum is registered, whereas none were observed in October 1928, though the net used in 1928 must have been less clogged than the one in use at that time in 1927. On the other hand, the fairly well-marked maximum in February 1929 was not observed in that month 1928, though it must be borne in mind that at that time the net was not functioning properly.

It is not improbable that winter maxima may be found to occur in this family as the warmer parts of the world are investigated, though the South African example does not appear to justify this conclusion entirely. The conclusion that seasonal variation is not constant can also be drawn on considering *Mesocyclops* in more detail (see Table III).

The periodicity of the plankton in tropical waters appears to be correlated with rainfall rather than with temperature changes. Apstein (1907) in the Lake of Colombo found that the majority of species yielded a maximum in June–August ("summer" dry season), some also in January ("winter" dry season). Crustacea showed a minimum in September when the autumn rains begin (no collection was made at the height of the wet season). Cunnington (1920) states that the plankton of Tanganyika is poorest in the wet season, the temperature being about the same as in the Lake of Colombo (25·9°–28·3° C. throughout the year). The conditions at Florida Lake are different to those described above, as the temperature varies from 7·5°–22·5° C., and it is usual to have summer rains (September–March) and a dry winter (April–August). Many of the phytoplanktons only appear in September and continue to be present during the summer; taken as a whole, the plankton is more abundant in number of species during the rainy summer season, with the exception of such groups as the Bacillariaceae (winter and spring maxima) and the Chrysophyceae (maximal July–October). It appears as if the Crustacea might be at a maximum just before the summer rains commence. The bulk of the plankton certainly appears to be more concentrated during the dry winter months, partly due to the abundance of *Melosira* and *Dinobryon*. In Searsville Lake, California, discussed in detail below, Scott (1927) recorded a decrease in the plankton due to sudden dilution by the March rains. In a shallow lake ("Sitoe") in Java, van Oye found periodicity to depend on the rainfall; after the rains begin first flagellates then ciliates, Crustacea and rotifers appear. At the end of the rains the plankton becomes scarce. Similar observations were made on "grass pans" in the Transvaal, more details of which will be found in a paper by Hutchinson, Pickford, and Schuurman (*in press*), but this sequence has not been observed in a permanent locality such as Florida Lake.

In Palestine (Krampner, 1928) in a permanent pool, which varies in temperature between 9·5° (February) and 37° (August), the majority of rotifers and Crustacea occur at the end of the wet season when the temperature is rising (March–May). Here conditions are different to those prevalent at Florida Lake (summer rains and dry winter), where the greatest number of species occurs at the end of spring or during the summer, *i.e.* during the rainy season.

The seasonal cycles of two localities which are in many ways comparable to Florida Lake merit special attention.

(a) **Searsville Lake, California.**

Attention has been concentrated (Scott, 1927) mainly on the phytoplankton in this paper; Crustacea were present, but only in relatively

small numbers ; Arachnida and Rotifera, which constituted the rest of the macroplankton, occurred in fair numbers during summer. The spring minimum due to dilution by the March rains, and perhaps comparable to the decrease in the total amount of plankton in Florida Lake in the wet summer season, has already been mentioned.

The Bacillariales were found to culminate in spring, while at Florida Lake a winter–spring (June–November) maximum was observed, the most conspicuous member of this family being *Melosira ambigua*. The Chlorophyceae yielded a summer–autumn (December–May) maximum at Florida Lake, and were not observed during July and August (*i.e.* winter), with the exception of *Crucigenia tetrapedia*, which was absent during January and February. At Searsville the Chlorophyceae were found to be dominant in summer. *Difflugia* was found to be evident for a short time in May and June and thereafter completely disappeared at Searsville. At Florida Lake it was found to be perennial, having a maximum in spring (September–November), there being about 400 per c.c. for the period 24/9/27 to 15/10/27. *Anabaena* attained a maximum in July, and formed the first " pseudo-bloom " of Searsville Lake ; at Florida Lake the genus attained a slight maximum in December and was found to be present during spring and summer only. In Searsville Lake *Euglena* was present throughout the entire season, having an increase in May, while at the end of August the climax is attained with an average of 5000 per c.c. forming a " bloom " in the stagnant bright green water. In Florida Lake the genus was fairly rare and was not observed during the period May–August. *Trachelomonas* was also found to be abundantly represented throughout the year in Searsville, yielding two maxima, one in January and another in March. In Florida Lake it was found to occur only from December–February and then rarely. *Peridinium* occurred constantly throughout the season at Searsville, the numbers being comparatively low at the beginning of the year ; in July a sudden increase culminated in an August maximum. Three species are recorded. At Florida Lake only two species occurred, a maximum occurring from June, culminating in the highest peak on the 27th August 1927 ; other smaller maxima occurred in May, July, and September 1928, and again in May and June 1929, giving the impression that this genus is most abundant during the period May–November, *i.e.* end of autumn, winter, and spring. *Dictyosphaerium* yielded comparatively small numbers in July, and yet was observed to be a conspicuous member of the plankton of Searsville ; at Florida Lake it was not observed during August, and had a small maximum in April. *Scenedesmus* was important at Searsville from the point of view of numbers ; in August, when the lake was drained, the water appeared to be an almost pure culture. From Florida Lake a few species are recorded, the dominant form being *S. quadricauda*, not observed during August.

Pediastrum was conspicuous at Searsville in one plankton count only (July); in Florida Lake it was found to be present throughout the whole year, yielding a small maximum in October.

In broad outline the seasonal succession in the two lakes would seem to be similar. The Bacillariales were responsible for spring and the Chlorophyceae and Myxophyceae for summer maxima. Eugleniniae were not observed at Florida Lake during June–August (winter), while *Peridinium* yielded a maximum for May–November (winter and spring), whereas at Searsville it was found that the Flagellatae persisted throughout the entire season.

Searsville Lake has been classified as a "tropical lake"; the temperature does not exceed 23° C., while the winter minimum is stated to be 4° C., and during winter the lake is never frozen. Florida Lake compares well with Searsville in this respect, as the temperature ranged from 7·5°–22·5° C. and is also never frozen. The term "tropical lake" as defined by Whipple is seen to be very wide. Scott regards Searsville Lake from an ecological standpoint as a "temperate" lake, with a seasonal swing from subarctic to a subtropical facies. A similar characterisation might be applied to Florida Lake.

(b) **Yan Yean Reservoir, Victoria, Australia.**

Only one locality in the Southern Hemisphere has been investigated seasonally, the Yan Yean Reservoir, near Melbourne, Victoria, Australia (West, 1909). Unfortunately only the phytoplankton has been considered. Here the temperature conditions are almost identical with those of Florida Lake, varying from 10° C. in July and August to 20°–25° C. in February. The cold-water diatoms *Asterionella* and *Fragilaria* are absent in both cases. The Yan Yean Reservoir differs from other warm-water lakes examined seasonally in having very few Cyanophyceae and a very rich desmid plankton, probably the result of local conditions; in Florida Lake both the Cyanophyceae and the desmid plankton are poorly represented.

The Yan Yean Reservoir lies 25 miles from Melbourne and is about 3 miles long, the average depth being a little over 24 feet. The temperature varies from 10° C. (July–August) to 25° C. (February); at Florida Lake the temperature has been registered at 7·5° C. (June) and 22·5° C. (January). The Yan Yean plankton is characterised by a scarcity of diatoms, resembling the plankton of the great lakes of Central Africa in having only *Melosira* common; *Asterionella* and *Fragilaria* being absent; in this respect Florida Lake compares well with the reservoir. The reservoir has a very rich phytoplankton, which reaches its greatest development in March and April, at the time when the Crustacea are least evident. The minimum

amount of phytoplankton occurs in September and October, in which months it is almost wanting. The great abundance of desmids in February–May is largely responsible for the qualitative richness of the Yan Yean reservoir, since this group is poorly developed in Florida the plankton of the latter is considerably less varied.

In the richness of its desmid flora the Yan Yean Reservoir offers a close parallel to the plankton of many of the lakes of the western parts of Great Britain. The paucity of the Cyanophyceae at Yan Yean has been commented on by West; this group, though somewhat better represented at Florida Lake, has as its only dominant member *Microcystis flos-aquae*.

Mallomonas and *Trachelomonas*, both absent at Yan Yean Reservoir, occurred at Florida Lake though not in great numbers. *Dinobryon cylindricum* and var. *divergens* attained their maximum very rapidly, in the Yan Yean, at a temperature from 18°–20° C., occurring in abundance from December to March; the forms disappeared with equal rapidity and were entirely absent from May to October. At Florida Lake *Dinobryon divergens* occurred very suddenly in September 1927 (4400 per c.c.), whereas a week before none were observed; in 1928–29 the species appeared to be present throughout the year. Maxima were attained in September 1927 and July 1928, *i.e.* at temperatures of 15·5° and 9° C., in this respect more in agreement with results obtained in European waters. *Peridinium Volzii* var. *australe* occurred in the plankton of the Yan Yean Reservoir, and yielded two maxima, one in November at a temperature of 15° C., and another in February at a temperature of 24·4° C. At Florida Lake *Peridinium* sp. was maximal on the 27th August 1927 (no temperature taken), and ? 20th May 1928 (15° C.), 15th September 1928 (14° C.), and ? May–June 1928 (14°–10° C.). *Botryococcus Braunii* occurred only in June and July in the Yan Yean Reservoir, whereas *Botryococcus protuberans* was found to be perennial in Florida Lake, yielding no marked maximum, though the species may have been slightly more abundant during June 1927 and November 1928 to May 1929. West considered *Sphaerocystis Schroeteri* and *Tetraspora lacustris* to be different stages of one and the same organism, and found the Sphaerocystis type to be flourishing from February to August and then giving rise to the imperfect Tetraspora type, which was abundant from September to December. (Nowadays this view is not accepted.) At various times the identification of *Sphaerocystis* in the Florida collections was found to be confusing, and it is quite likely that this genus may have been present at times, when it was not identified as such. It has been recorded as very rare from April to June and rare from September to March. *Pediastrum duplex clathratum* was observed in March only in the Yan Yean Reservoir, while in Florida Lake the species was found to be perennial, yielding a possible maximum in October.

Kirchneriella lunaris was present only from January to March, and then it was rare in the Yan Yean Reservoir; in Florida Lake *Kirchneriella obesa* was observed during September–June.

Melosira granulata occurred abundantly and was never absent from the Yan Yean collections; it is stated to have been most conspicuous from November to April, and to have reached its maximum in February (21° C.); auxospore formation took place in January. In Florida Lake *Melosira ambigua* was found to be perennial and to be most conspicuous from May to November, the maximum being attained in June (*c.* 10° C.) and October (*c.* 16° C.); auxospore formation was recorded by Miss Rich to have taken place in January (*c.* 21° C.). It is striking to note that *Melosira ambigua*, in which a number of the forms of *M. crenulata* are now included, is recorded from Florida Lake, as *M. granulata* is said to be the chief tropical and subtropical diatom (West, 1909; Apstein, 1907). *M. granulata* has been observed in several plankton samples collected in the Transvaal. *Tabellaria flocculosa*, although never frequent, was present in all the collections, except those made in August in the Yan Yean Reservoir; in Florida Lake the species also never occurred abundantly, and was not observed from January to March.

There was no phase in the Yan Yean plankton in which blue-green algae dominate such as occurs in so many European and North American lakes; no such phase was observed in the Florida Lake plankton. *Microcystis flos-aquae*, never dominant, appeared to be perennial in Florida Lake, possibly more abundant from November to March.

Oscillatoria Agardhii was common in July in the Yan Yean plankton, whereas *Oscillatoria* sp. was observed only in July in the Florida collections. *Chroococcus limneticus* var. *subsalsus* occurred abundantly in April in Yan Yean; in Florida *Chroococcus minutus* (?) was never plentiful, but was observed to be slightly more abundant in November and December.

West states that the Crustacea were beginning to be more conspicuous in April, and became very evident, forming a relatively large amount of the plankton in May; Crustacea remained dominant during June–September, which is also more or less the case in Florida Lake.

Three periods of the year are distinguished by West for Yan Yean Reservoir:—

1. November–January, temperature 15°–20° C., *Melosira granulata* and *Dinobryon cylindricum* and var. *divergens* dominant.
2. February–May, temperature 25°–20° C., Desmids dominant.
3. June–October, temperature 10°–13° C., Crustacea dominant, very little phytoplankton.

The following periods, based on broad lines, may be recognised for Florida Lake:—

1. May–October, temperature 16°–7·5°–17° C., *Melosira ambigua* and *Dinobryon divergens.*
   June–October, temperature 11·5°–7·5°–17° C., Crustacea.
2. September–May, temperature 13°–22·5°–16° C., Chlorophyceae, more numerous Cyanophyceae and Rotatoria.

The interest of the present investigation is clear, as it is the first investigation on seasonal succession for both zoo- and phytoplankton in the Southern Hemisphere, and serves as a comparison with these other Southern Hemisphere observations on phytoplankton. The differences between the two localities are clearly very great, as is to be expected from the great qualitative dissimilarity of the plankton of Florida Lake and the Yan Yean Reservoir. The most noteworthy similarity is in the time of the maximum abundance of Crustacea (June–October).

Florida Lake, Potchefstroom Dam, and Hartebeestpoort Dam have been considered together in a previous paper on the hydrobiology of pans and other inland waters of South Africa (Hutchinson, Pickford, and Schuurman) under the heading, " Artificial Lakes in the Transvaal." These dams are built for irrigation purposes ; the water is clear and colourless, and is free from any products of gold extraction or other commercial enterprise. The pH in both cases has been recorded to be 7·2 ; a comparison of the chemical data is given on p. 337.

In view of the presence of certain striking species in these three localities, it was considered advisable to publish microphotographs of plankton samples from Potchefstroom Dam and Hartebeestpoort Dam for comparison with those published of Florida Lake.

The zooplankton was, in both cases, in most respects comparable to that of Florida Lake. At the end of summer (25th March 1928), the two characteristic summer rotifers, also found in Florida Lake, *Brachionus falcatus* and *Tetramastix opoliensis*, were present in Potchefstroom Dam, indicating a seasonal cycle similar to that found in Florida Lake ; these, as well as *Trichocerca chattoni*, were also present in Hartebeestpoort Dam on 29th April 1928. Professor P. de Beauchamp, in connection with the identification of *Trichocerca chattoni* (10th October 1930), remarked that *T. chattoni* and *T. cylindricus* were characteristic of plankton in which Chroococcaceae occurred. In Florida Lake more *Trichocerca chattoni* as well as more Microcystis were present than in Hartebeestpoort Dam, while in Potchefstroom Dam Microcystis was very rare or absent, and *T. chattoni* not observed.

Summary.

1. A study has been made of the seasonal variation of the tow-net plankton of Florida Lake, a shallow artificial lake of mesotrophic or

eutrophic *facies*, lying at an altitude of 5700 feet (1740 m.) on the Witwatersrand, Transvaal, Union of South Africa.

2. An annual variation in temperature of the surface water from 7·5° C. to 22·5° C. is recorded. The pH of the water varied little, lying between 6·2 and 7·0.

3. Very pronounced seasonal variation in the plankton is recorded. The total number of organisms was greatest between June and October, after which month a decline occurred. Large amounts of *Melosira* and *Dinobryon* initiated a new period of abundance in May. The period of the minimum plankton coincides with that of the maximum rainfall.

4. In general the greatest number of species was observed during the summer minimum.

5. From May to October *Melosira ambigua* and *Dinobryon divergens* were the commonest phytoplanktonic organisms. Chlorophyceae were most abundant from September to May, and such Myxophyceae as occurred had either summer maxima or were only found during that season.

6. Rotifers were most abundant from September to May, most species having a single spring or summer maximum. This is particularly striking in the case of *Tetramastix opoliensis* and *Brachionus falcatus*, two species which, though infrequent in Europe, are apparently common in tropical Africa.

7. In general the Crustacean plankton is most abundant from June to October; the variations in numbers of individual species were irregular and differed considerably in the two years during which the investigation was carried out.

8. A study of the surface plankton at three-hourly intervals through a 24-hour period in June (winter) showed a marked concentration of *Chaoborus* larvae in the surface water about two hours after sunset. Some of the Crustacea and phytoplanktonic forms also appeared to ascend after sunset; the movements of the latter though well marked may have been due to convection currents.

9. Cyclomorphosis is practically absent in the plankton community of Florida Lake. Ephippial females of *Ceriodaphnia dubia* occurred in both the early winter (May 1929, June 1927, 1929) and early summer (November–December 1927). *Daphnia longispina* produced ephippia only in the spring and early summer (October 1927, November 1928).

10. The seasonal sequence of planktonic organisms of Florida Lake is discussed in relation to that known elsewhere, including two localities with comparable temperature conditions which are considered in detail. Searsville Lake, California (Scott, 1927), shows a sequence of phytoplanktonic forms which is broadly comparable to that found in Florida Lake. The Yan Yean Reservoir, Victoria, Australia (West, 1909), unlike Florida,

has a very rich desmid plankton, and no striking parallelism between the succession of the phytoplankton here and in Florida Lake can be traced. Unfortunately in this, the only previously studied locality in the Southern Hemisphere, the zooplankton was not investigated, but it appears that in the Yan Yean Reservoir, as in Florida Lake, Crustacea are most abundant from June to October.

LITERATURE.

Abderhalden, E. (1929): Handbuch der biologischen Arbeitsmethoden, Abt. ix, "Methoden zur Erforschung der Leistungen des tierischen Organismus," Teil 2, 2 Hälfte, Heft 3.

Allen, E. J. (1919): "A Contribution to the Quantitative Study of Plankton," Journ. Mar. Biol. Assoc. of United Kingdom, vol. xii, No. 1.

Allen, E. W. (1920): "A Quantitative and Statistical Study of the Plankton of the San Joaquin River and its Tributaries in and near Stockton, California, in 1913," Univ. California Publ. Zool., vol. xxii.

Apstein, C. (1907): "Das Plankton im Colombosee auf Ceylon," Zool. Jahrb. (Abt. f. Syst.), Bd. xxv, p. 201.

Auerbach, M., Maerker, W., and Schmolz, J. (1924): "Hydrographisch-biologische Bodensee Untersuchungen 1," Archiv f. Hydrobiol., Suppl. III, p. 597.

Bachman, H. (1924): "Das Phytoplankton der Schweizerseen (Vergleichende Plankton-studien)," Verhandl. d. Schweizer Naturforsch. Gesellschaft, Luzern, Teil 2, pp. 15–30.

Beauchamp, P. de (1928): "Coup d'oeuil sur les Recherches récentes relatives aux Rotiferès. V. Le Variation," Bull. Biol. Fr. Belg., vol. lxii, p. 51.

Bigelow, H. B. (1924): "Plankton of the Offshore Waters of the Gulf of Maine," Bull. Bur. of Fisheries, vol. xl, pt. ii.

Bioret, G. (1925): "Le Plancton de l'Étang Saint-Nicolas," Extr. du Bull de la Soc. d'Études Sci. d'Angers, tome lv, 1925–1926.

Birge, E. A. (1897): Trans. Wisconsin Acad., vol. ii, p. 301.

Birge, E. A., and Juday, C. (1922): "The Inland Lakes of Wisconsin. The Plankton, its Quantity and Chemical Composition," Wisconsin Geol. and Nat. Hist. Survey, Bull. 64, No. 13.

Bles, E. J. (1929): "Arcella: A Study in Cell Physiology," Quart. Journ. of Microsc. Sci., vol. lxxii, pt. iv.

Brauer, A.: Die Süsswasser fauna Deutschlands, Hefte 11, 14.

Brehm, V. (? 1926): "Über die Tiefenfauna japanischer Seen.," Archiv f. Hydrobiol., Bd. xviii, pp. 135–150.

Brehm, V. (1927): "Neues über die Fauna unterirdischer Gewässer—I," Intern. Rev. der ges. Hydrobiol. und Hydrogr., Bd. xvii, Hefte 3–4.

Brehm, V. (1928): "Vorläufige Mitteilung über die Süsswasserfauna Neu-Seelands," I. Zool. Anz., Bd. lxxv, Hefte 7–10, 15/2/28; II., *Ibid.*, Bd. lxxviii, Hefte 11–12, 1/10/28; III., *Ibid.*, Bd. lxxix, Hefte 5–6, 15/11/28.

Brehm, V. (1913): "Ergebnisse einer Botanischen Forschungsreise nach Deutsch-Oost

Afrika und Süd Afrika (Kapland, Natal, und Rhodesien)," Denkschr. Mathm.-Naturw. Klasse d. Kaiserl. Akad. d. Wissensch., Bd. lxxxviii.

BREHM, V. (1926): "Die Mikrofauna des Alkalischen Sees auf Pantelleria," Senckenbergiana, Bd. viii, Hefte 5–6.

BREHM, V. (? 1926): "Hydrobiologische Untersuchungen aus Uruguay," Archiv f. Hydrobiologie, Bd. xix, pp. 719–722.

BREHM, V., and RUTTNER, F. (1926): "Die Biocönosen der Lunzer Gewässer," Intern. Rev. der ges. Hydrobiol. und Hydrogr., Bd. xvi, Hefte 5–6.

BRUTSCHY, A. (? 1916): "Die Vegetation und das Zooplankton des Hallwiler Sees," Int. Rev. Hydrobiol., vol. x, p. 91.

BRYCE, D. (1924): "The Rotifera and Gastrotricha of Devil's and Stump Lakes, North Dakota, U.S.A.," Journ. Quek. Microsc. Club, vol. xv.

BRYCE, D. (1913): "The Rotifera of Devil's Lake, with description of a new Brachionus," Journ. Quek. Microsc. Club, vol. xii.

CARPENTER, K. E. (1928): Life in Inland Waters.

CROW, W. B. (1923): "The Taxonomy and Variation of the Genus *Microcystis* in Ceylon," New Phytologist, vol. xxii, p. 59.

CUNNINGTON, W. A. (1920): "The Fauna of the African Lakes: A Study in Comparative Limnology, with Special Reference to Tanganyika," Proc. Zool. Soc. London.

DAKIN, W. J. (1907–1908): "Methods of Plankton Research," Proc. and Trans. of Liverpool Biol. Soc., vol. xxii.

DECKSBACH, N.: "Studien über das Zooplankton des Petschora Beckens und der südlichen Nebenflüsse der Dwina (Nord-Russland)," Intern. Rev. der ges. Hydrobiol. und Hydrogr., Bd. xiv, Hefte 5–6.

DES CILLEULS, J. (1927): "Le phytoplancton du Thouet, affluent de la Loire," Extr. des C.R. Acad. des Sciences.

DES CILLEULS, J. (1926): "Le phytoplancton de la Loire," Extr. des C.R. Acad. des Sciences.

DES CILLEULS, J. (1927): "Généralités sur le Plancton," C.R. Soc. L.S. et A. du Saumurois.

EDDY, S. (1927): "The Plankton of Lake Michigan," Bull. Dept. Registr. and Educ. Nat. Hist. Survey, vol. xvii, Art. iv.

FLÜCK, H. (1926): "Beiträge zur Kenntnis des Phytoplanktons des Brienzersees," Thesis, Zürich Techn. Hochsch. Aarau.

FRITSCH, F. E. (1903): "Remarks on the Periodical Development of the Algae in the Artificial Waters at Kew," Ann. Bot., vol. xvii, No. 65.

FRITSCH, F. E., and RICH, F. (1929): "Contributions to our Knowledge of the Freshwater Algae of Africa: Freshwater Algae from Griqualand West," Trans. Roy. Soc. S. Afr., vol. xviii, pts. i and ii.

FRITSCH, F. E., and RICH, F. (1924): "Contributions to our Knowledge of the Freshwater Algae of Africa: Freshwater and Subaerial Algae from Natal," Trans. Roy. Soc. S. Afr., vol. xi.

FRITSCH, F. E., and RICH, F. (1925): "On a Deposit of Diatomaceous Earth from Ermelo, Transvaal," Trans. Roy. Soc. S. Afr., vol. xii, pt. iv.

FRITSCH, F. E., and RICH, F. (1909): "Biology and Ecology of the Algal Flora of Abbot's Pool, near Bristol," Bristol Nat. Soc. Proc., 4th ser., vol. ii, pt. ii.

FRITSCH, F. E., and RICH, F. (1913 : " Studies on the Occurrence and Reproduction of British Freshwater Algae in Nature : A Four Years' Observation of a Freshwater Pond," Extr. des Annales de Biologie Lacustre, tome vi, 1913.

GAJL, K. (1924) : " Über zwei faunistische Typen an der Umgebung von Warschau von Untersuchungen an Phyllopoden und Copepoden (excl. Harpacticidae)," Bull. Acad. Pol. Ser. B. Sci. Nat., p. 13.

GAUTHIER, H. (1928) : Recherches sur la Faune des Eaux continentales de l'Algérie et de la Tunisie.

GRAN, H. H. (1912) : " Preservation of Samples and Quantitative Determination of the Plankton," Conseil Perm. Intern. p. l'exploration de la Mer. Publ. de Circonstance, No. 62.

GRAN, H. H. (1927) : " Über die Planktonproduktion im Hurdals-See," Avh. Urgitt av Det Norske Vidensk. Akad. Oslo. I. Matem.-Naturvid. Klasse, No. 1.

GURNEY, R. (1923) : " The Crustacean Plankton of the English Lake District," Journ. Linn. Soc., vol. xxxv, No. 236, pp. 411–447.

HAEMPEL, O. (1923) : " Zur Kenntnis einiger Alpenseen III, Der Millstättersee," Archiv f. Hydrobiol., Bd. i, p. 346.

HAEMPEL, O. (1925) : " Zur Kenntnis einiger Alpenseen IV, Der Attersee," Intern. Rev. Hydrobiol., Bd. xvi, p. 180.

HARRING, H. K. (1913) : Synopsis of the Rotatoria.

HARRING, H. K., and MYERS, F. J. (1922–1928) : The Rotifers of Wisconsin, vols. i–iv. ; Trans. Wisconsin Acad. Sci., Arts and Letters, vols. xx–xxiii.

HARTMANN, O. : " Studien über den Polymorphismus der Rotatorien," Archiv f. Hydrobiol., Bd. xii, p. 209.

HASTINGS, A. B. (1929) : " Phylactolaematous Polyzoa from the ' Pans ' of the Transvaal," Ann. and Mag. of Nat. Hist., ser. 10, p. 129.

HODGETTS, W. J. (1926) : " Contributions to our Knowledge of the Freshwater Algae of Africa : Some Freshwater Algae from Stellenbosch, Cape of Good Hope," Trans. Roy. Soc. S. Afr., vol. xiii, pt. i.

HÖLL, K. (1928) : Ökologie der Peridineen Pflanzenforschung, Heft 11.

HUBER-PESTALOZZI, G. (1928) : " Das Plankton natürlicher und künstlicher Seebecken Südafrikas," Abstract in Intern. Rev. ges. Hydrobiol. und Hydrogr., Bd. xix.

HUDSON, C. T., and GOSSE, P. H. : The Rotifera, vols. i, ii, and Supplement.

HUTCHINSON, G. E. (1929) : " A Revision of the Notonectidae and Corixidae of South Africa," Ann. S.A. Museum, vol. xxiii.

HUTCHINSON, G. E. (1931) : " New and Little-known Rotatoria from South Africa," Ann. and Mag. Nat. Hist., ser. 10, vol. vii.

JENKIN, P. M. (1929) : " Biology of Lakes in Kenya," Nature, 12th October 1929.

JEWELL, M. E., and BROWN, H. W. (1929) : " Studies on Northern Michigan Bog Lakes," Ecology, vol. x, No. 4.

JUDAY, C. (1916) : " Limnological Studies on some Lakes in Central America," Trans. Wisc. Acad., vol. xviii, p. 214.

JUDAY, C. (1903) : " The Diurnal Movement of Plankton Crustacea," Trans. Wisc. Acad., vol. xiv, pt. ii, p. 534.

JUDAY, C. (1922) : " Quantitative Studies of the Bottom Fauna in the Deeper Waters of Lake Mendota," Trans. Wisc. Acad., vol. xx.

KIEFER, F. (1928): "Beiträge zur Copepodenkunde (VIII): Diaptomiden und Cyclopiden aus Südafrika," Zool. Anz., Bd. lxxvi, p. 8.

KIEFER, F. (1929): "Neue und wenig bekann. Süsswasser-Copepoden aus Südafrika," Zool. Anz., Bd. lxxx, p. 309.

KIKUCHI, K. (1930): "Diurnal Migration of Plankton Crustacea," Quart. Rev. Biology, vol. v, No. 2, pp. 189–206.

KIKUCHI, K. (1927): "Notes on the Diurnal Migration of Plankton in Kizaki Lake," Journ. Coll. Agric. Imp. Univ. Tokyo, vol. ix, 3, p. 177.

KOFOID, C. A. (1908): "The Plankton of the Illinois River, 1894–1899, with Introductory Notes upon the Hydrography of the Illinois River and its Basin.—Pt. II: Constituent Organisms and their Seasonal Distribution," Bull. Illinois State Lab. Nat. Hist., vol. viii.

KRAMPNER, A. (1928): "Wandlungen der Kruster- und Rotatorien Fauna eines perennierenden und eines temporalen Tümpels bei Tel Aviv (Palestina) im Verlauf eines Jahres," Intern. Rev. Hydrobiol., Bd. xix, p. 281.

KÜHL, F. (1928): "Untersuchungen über das Zentrifugen Plankton und das Netzplankton des Walchensee und der Kochelsee in den Jahren, 1921–23," Archiv f. Hydrobiol., Suppl. 6, p. 96.

MARSHALL, S. M., and ORR, A. P. (1927): "The Relation of the Plankton to some Chemical and Physical Factors in the Clyde Sea Area," Journ. Mar. Biol. Assoc. of United Kingdom, vol. xiv, No. 4.

MARSHALL, S. M., and ORR, A. P. (1928): "The Photosynthesis of Diatom Cultures in the Sea," Journ. Mar. Biol. Assoc. of United Kingdom, vol. xv, No. 1.

OSTENFELD, C. H., and WESENBERG-LUND, C. (1905): "A Regular Fortnightly Exploration of the Plankton of the Two Icelandic Lakes, Thingvallavatn and Myvatn," Proc. Roy. Soc. Edin., vol. xxv, p. 1092.

PASCHER, A. (1914): "Über Flagellaten und Algen," Ber. Deutschl. Bot. Ges., Bd. xxxii, pp. 136 *et seq.*

PASQUINI, P. (1924): "Per una maggiore conoscenza della fauna pelagica del Lago Trasimeno," Atti R. Acad. Lincei, 33.

PELOSSE, J. (1926): "Sur les Entomostracées de la fauna pélagique du lac du Bourget (Savoie)," C.R. Acad. Sci., 183.

PLAYFAIR, G. I. (1913): "Plankton of the Sydney Water Supply," Proc. Linn. Soc. of New South Wales, vol. xxxvii, p. 512.

PORETZKY, W.: "Einige Beobachtungen über das Leben des Teiches im Parke des Botanischen Gartens im Zusammenhang mit der Überschwemming am 23 Sept. 1924," Arbeit des Hydrobiol. Lab. der Bot. Gart.

PORETZKY, W. (1927): "Beiträge zur Erforschung von Bewüchsen in den Gewässern Kareliens—I," Bewüchse fliessender Gewässer Bericht. d. Akad. Borodin Biol. sussw. St., Bd. v.

PORETZKY, W. (1928): "Preliminary Report on the Co-operative Survey of Lake Erie, season of 1928," Bulletin of the Buffalo Society of Natural Sciences, vol. xiv, No. 3.

RICH, F. (1930): "Freshwater Phytoplankton," S.A. Journ. Nat. Hist., vol. vi, p. 369.

ROBERT, H. (1925): "Sur la variabilité de quelques Especes Planctoniques du Lac de Neuchatel," Ann. Biol. Lac., 14.

ROUSSELET, C. (1906): "Contribution to Our Knowledge of the Rotifera of South Africa," Journ. Roy. Microsc. Soc.

ROY, J. (1926): "Sur les Copépodes libres de la Vallée du Loir," Ann. Biol. Lac., 15.

SARS, G. O. (1916): "The Freshwater Entomostraca of the Cape Province (Union of S. Africa).—Pt. I, Cladocera," Ann. S.A. Mus., vol. xv, p. 303.

SARS, G. O. (1926): "The Freshwater Entomostraca of the Cape Province (Union of S. Africa).—Pt. III, Copepoda," Ann. S.A. Mus., vol. xxv, p. 85.

SCHÖRLER, B., THALLWITZ, J., and SCHILLER, K. (1906): "Pflanzen und Tier-welt des Moritzburger Gross-teiches bei Dresden," Ann. Biol. Lac., 1.

SCHREYER, O.: "Die Rotatorien der Umgenung von Bern," Intern. Rev. ges. Hydrobiol., Bd. ix, pp. 311, 491.

SCOTT, F. M. (1927): "Introduction to the Limnology of Searsville Lake," Stanford Univ. Publ. Univ. Ser. Biol. Sci., 5.

SMITH, G. M. (1920 and 1924): Phytoplankton of the Inland Lakes of Wisconsin, pts. i and ii.

STEPHENS, E. L. (1924): "Notes on the Aquatic Flora of South Africa," S.A. Journ. Sci., vol. xxi, p. 339.

STEPHENS, E. L. (1929): "Freshwater Aquatic Vegetation of the South-Western District in 'The Botanical Features of the South-Western Cape Province,'" Wynberg, Speciality Press.

THIENEMANN, A. (1926): Die Binnegewässer Mitteleuropas, Bd. i, iv, v.

VAN OYE, P. (1927): "Données concernant la distribution geographique des Algues au Congo Belge," Rev. Zool. Africaine, vol. xv, fasc. 3, Suppl. Bot.

VAN OYE, P. (1926): "Le Potamoplancton du Ruki au Congo Belge et des pays chauds en general," Intern. Rev. der ges. Hydrobiol. und Hydrogr., Bd. xvi, Heft 12.

VAN OYE, P. (1925): "Flagellates du Congo Belge," Bull. Soc. Roy. Botan. Belgique, vol. lviii, fasc. 1.

VAN OYE, P. (1927): "Le genre Trachelomonas au Congo Belge," Bull. Soc. Roy. Botan. Belgique, vol. lix, fasc. 2.

VAN OYE, P. (1926): "Six Rhizopodes nouveaux du Congo Belge," Archiv de Zool. Exp. et Générale, tome lxv, No. 3.

VAN OYE, P. (1926): Tropisch-Algologische Aanteekeningen. Kon. Vlaam. Acad.

VAN OYE, P. (1927): "Handleiding bei de praktische Studie der niet-parasitaire Mikroorganismen," Kon. Vlaam. Acad., No. 8.

VAN OYE, P. (1927): "Over de Wier flora van Belgisch-Kongo," Botan. Jahrb., Bd. xx, pp. 93–144.

VAN OYE, P. (1927): "Rhizopoden en Heliozoën van Belgisch-Kongo," Natuurw. Tydschr., Bd. i.

VIETS, K. (1930): "Hydracarina aus Transvaal," Zool. Anz., vol. lxxxix, p. 285.

VIRIEUX, J. (1916): "Recherches sur le plancton des lacs du Jura central," Ann. Biol. Lac., tome viii.

WAGLER, E. (1927): "Über die 'Schwebefortsätze' der Daphnien," Zool. Anz., Bd. lxxiv, Hefte 11–12.

WANG, CHIA, CHI (1928): "Ecological Studies of the Seasonal Distribution of Protozoa in a Freshwater Pond," Journ. Morph. and Physiol., vol. xlvi, No. 2.

WARD, H. B., and WHIPPLE, G. C.: Freshwater Biology.

WATZKA, M. (1928): "Die Rotatorienfauna der Cakowitzer Zuckerfabriksteiche und Versuche über das Auftreten von Rotatorien Männchen und über die Entwicklungszeit der Dauersier," Intern. Rev. Hydrobiol., Bd. xix, p. 430.

WESENBERG-LUND, C. (1926): "Contributions to the Biology and Morphology of the genus *Daphnia*, with some Remarks on Heredity," D. Kgl. Danske Vidensk. Selsk. Skrifter. Naturvidensk. Ogmatham. Afd., 8, vol. xi, p. 2.

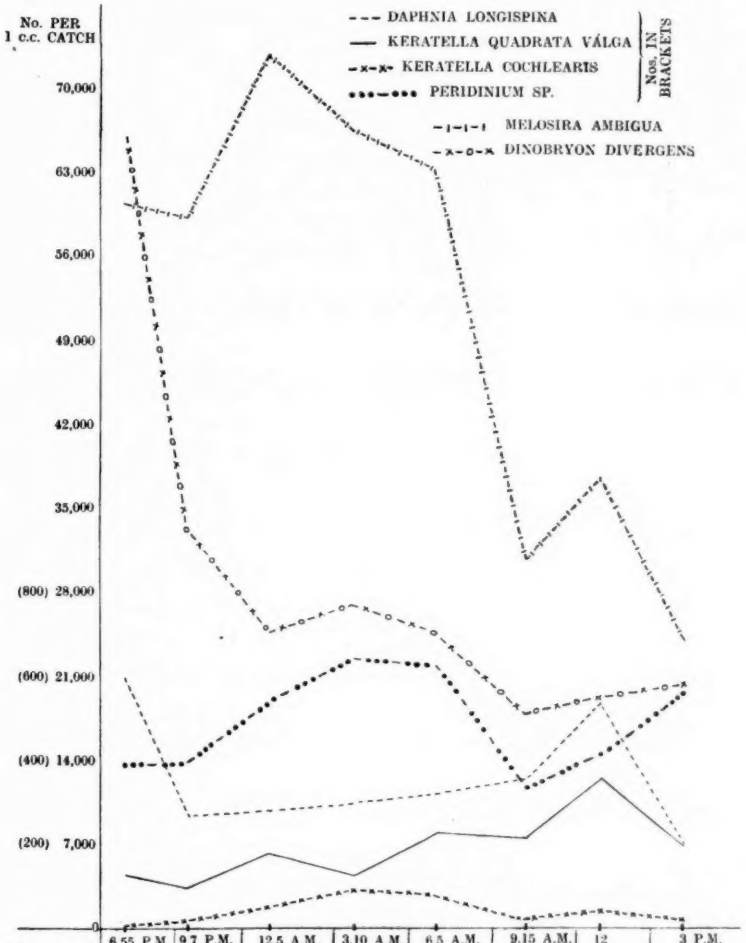
WEST, G. S. (1907–1909): "Report on the Freshwater Algae, including Phytoplankton of the Third Tanganyika Expedition, conducted by W. A. Cunnington, 1904–1905," Journ. Linn. Soc. Bot., vol. xxxviii.

WEST, G. S. (1909): "The Algae of the Yan Yean Reservoir, Victoria: A Biological and Ecological Study," Journ. Linn. Soc. Bot., vol. xxxix.

WEST and FRITSCH (1927): British Freshwater Algae.

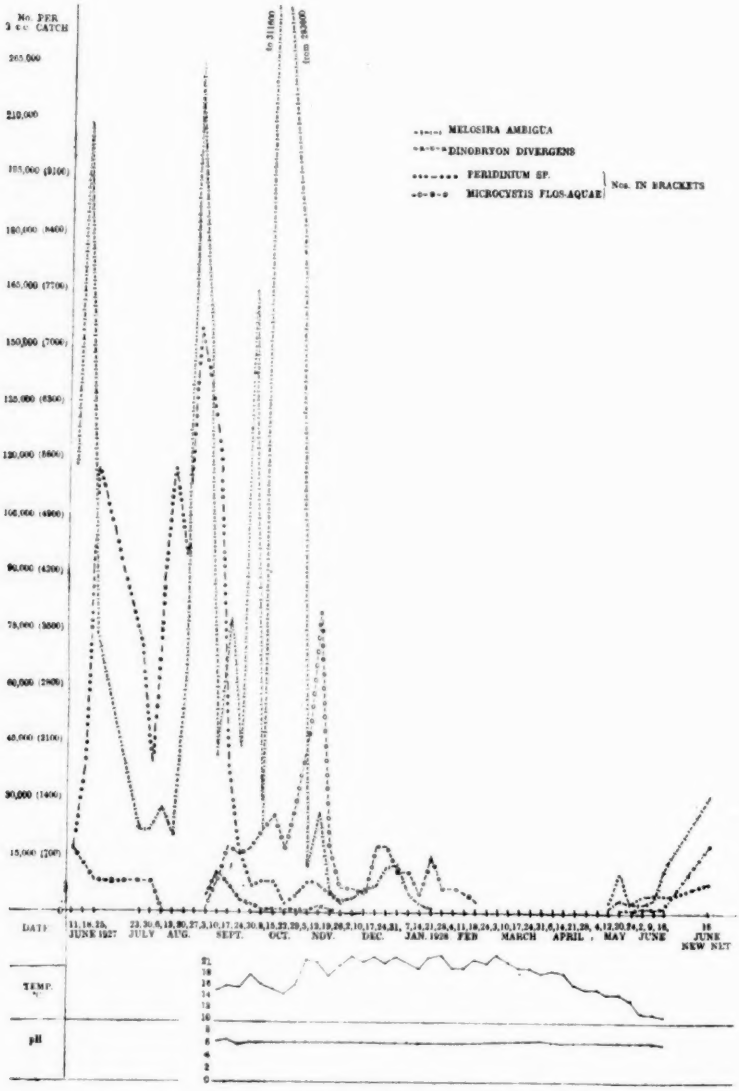
WEST, W., and WEST, G. S. (1912): "On the Periodicity of the Phytoplankton of some British Lakes," Journ. Linn. Soc. Bot., vol. xl.

ZIEGELMEYER, W. (1927): "Versuch der Darstellung von Wanderungen der planktischen Tierwelt," Zeitschr. Morph. und Okol. Tiere, Bd. viii.

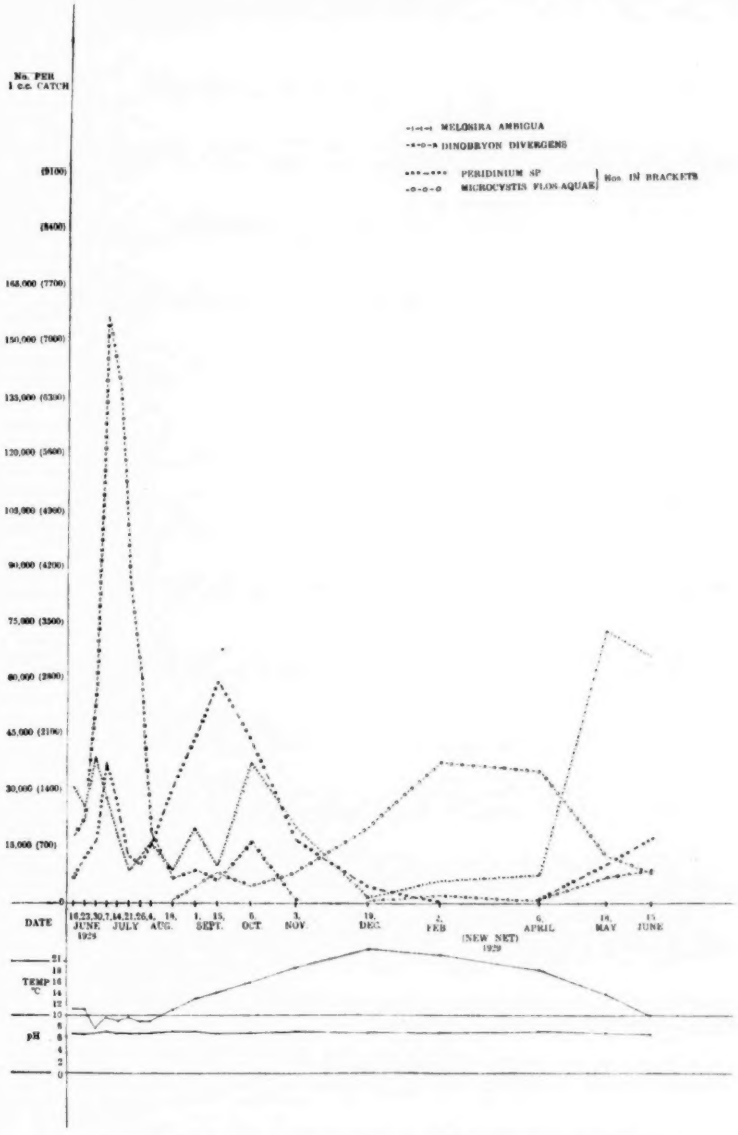


TIME AND DATE	6.55 P.M. JUNE 15	9.7 P.M.	12.5 A.M. MIDNIGHT 16	3.10 A.M.	6.5 A.M.	9.15 A.M.	12 NOON	3 P.M.
TEMP. °C.	12	11·5	11	10·5	10·5	11	11·5	11·5
pH	6·79	6·75	6·75	6·66	6·62	6·62	6·59	6·66
TURBIDITY CM.	26	25·5	24·5	28	40	48 SHADE 52 SUN	53 58	53 58

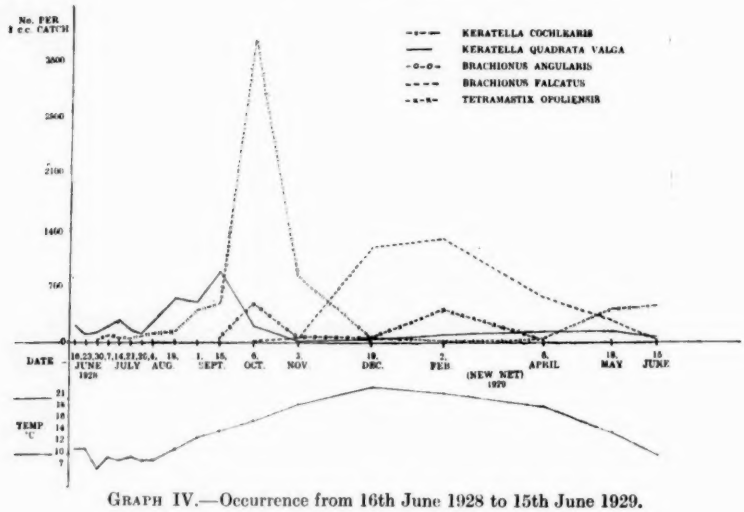
GRAPH I.—Vertical Migration 15th to 16th June 1928.



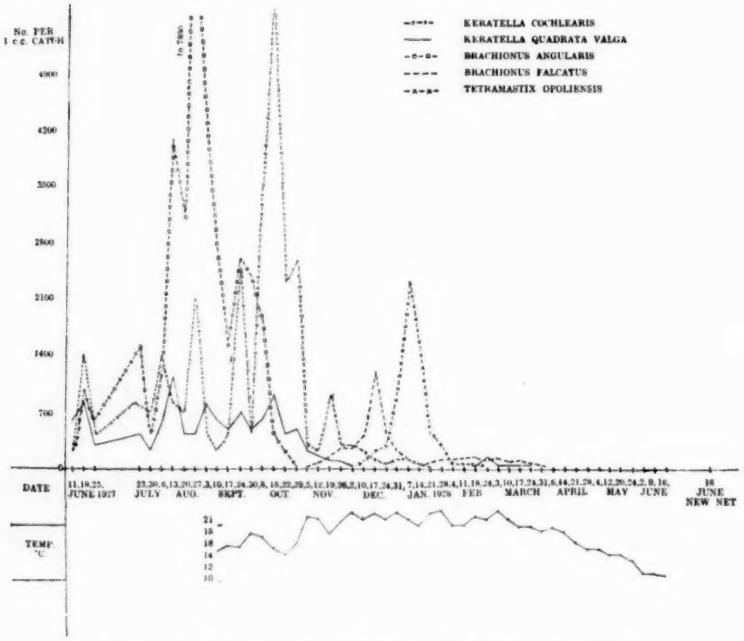
GRAPH II.—Occurrence from 11th June 1927 to 16th June 1928.



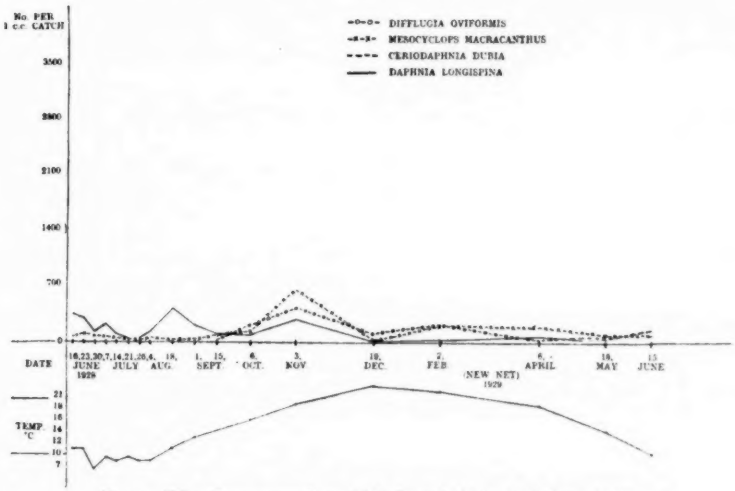
GRAPH III.—Occurrence from 16th June 1928 to 15th June 1929.



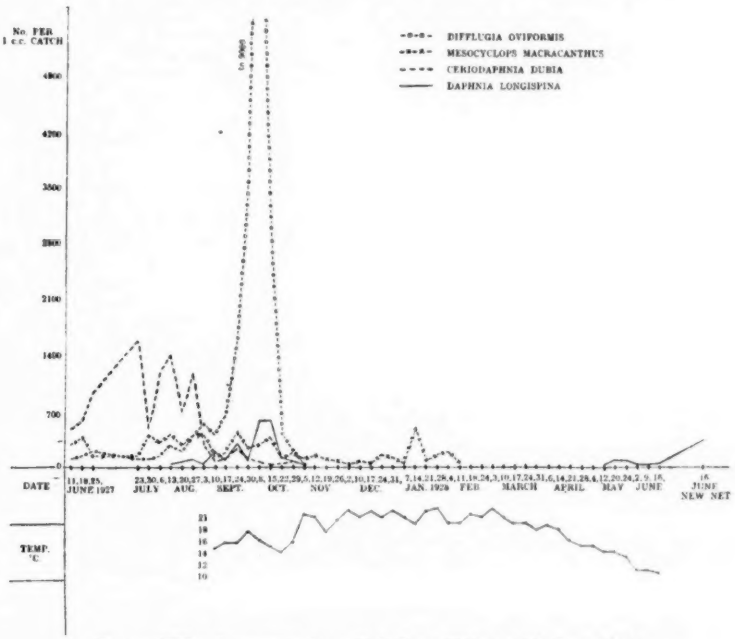
GRAPH IV.—Occurrence from 16th June 1928 to 15th June 1929.



GRAPH V.—Occurrence from 11th June 1927 to 16th June 1928.



GRAPH VI.—Occurrence from 16th June 1928 to 15th June 1929.



GRAPH VII.—Occurrence from 11th June 1927 to 16th June 1928.

TABLE

Actual Numbers of various Plankton Constituents per

	June 1927.			July.		August.			
Date	11	18	25	23	30	6	13	20	27
Temp. ° C.	..	..	..	..	..	..	..	..	..
pH	..	..	..	..	..	..	..	..	..
Peridinium sp.	750	1750	5500	3300	1800	4100	5500	4400	7200
Dictyosphaerium pulchellum / *D. ehrenbergianum*	p*	p	p	p	p	p	p	p	p
Kirchneriella obesa var. *aperta*	..	..	..	..	..	..	..	..	..
Staurastrum paradoxum	..	..	..	p	p	p	p	p	p
Staurastrum schuurmani	..	..	..	..	..	..	..	..	..
Staurastrum subvestitum	..	..	..	..	..	..	..	..	..
Pediastrum duplex var. *clathratum.*	200	200	p	p	p	100	p	p	p
Melosira ambigua	118400	208000	73200	21600	21600	27600	20800	65600	264800
Microcystis flos-aquae	800	600	400	400	400	p	p	p	p
Dinobryon divergens	..	..	..	..	..	..	..	..	..
Mallomonas producta var. *marchica.*	400	400	p	p	p	p	p	p	p
Difflugia oviformis	100	150	200	100	100	150	300	210	380
? Actinosphaerium	..	..	..	..	..	..	..	..	..
Synchaeta pectinata	30	50	50	10	10	60	200	150	130
Keratella cochlearis	200	1400	400	800	700	1400	800	700	2100
Keratella quadrata valga	600	800	300	400	200	600	1100	400	400
Brachionus angularis	200	1000	600	1500	400	1200	4100	3100	7800
Brachionus falcatus	..	..	..	..	..	..	..	..	..
Tetramastix opoliensis	..	..	..	..	..	..	..	..	..
Bosmina longirostris	120	500	545	740	670	1150	850	430	570
Ceriodaphnia dubia	495	600	940	1570	470	1200	1400	700	1200
Daphnia longispina	..	..	..	..	..	p	30	40	90
Mesocyclops macracanthus	300	380	150	140	410	310	420	230	390
Paradiaptomus colonialis	3	4	3	2	5	4	5	3	3

* p = present.

III.

1 *c.c.*, 11*th June* 1927–16*th June* 1928–15*th June* 1929.

September.					October.				November.				Dec.
3	10	17	24	30	8	15	22	29	5	12	19	26	2
..	15·5	16·5	16·2	18·8	17	16	15	16·8	21·5	21	18·5	20·5	22
..	6·8	7	6·2	6·5	6·4	6·5	6·6	6·4	6·3	6·5	6·4	6·3	6·3
6500	5600	1800	700	300	400	400	100	200	400	350	200	100	p
p	200	400	200	200	200	200	p	p	p	200	200	200	200
..	200	1400	1200	200	200	100	100	200	100	p	p	p	p
p	p	200	200	400	400	300	p	p	p	p	200	300	1600
..	200	400	200	400	400	200	p	p	p	p	200	500	1200
..	..	..	..	..	..	..	..	p	p	p	400	500	800
p	200	200	100	200	400	600	300	500	100	100	200	100	200
151600	41200	77800	43600	164400	22400	311600	283600	180000	11600	25600	5200	2800	3200
p	400	800	700	800	1000	1200	800	1400	2200	3700	800	300	300
4400	10400	7000	3200	2400	400	400	400	200	400	1500	500	p	p
p	400	400	400	300	200	800	12800	1600	400	100	p	p	p
570	400	700	1700	3700	9000	3000	400	200	p	p	p	p	p
..	3600	1600	2800	24800	400	p	p	p	p	p	p	p	p
100	60	200	800	200	200	50	25	15	145	70	p	p	p
400	200	400	2500	400	3500	5700	2300	2600	300	200	900	300	300
800	600	500	700	500	600	900	400	500	200	200	100	100	p
4900	2600	1500	2600	2400	1800	400	200	100	p	p	p	p	p
..	..	..	..	..	p	p	p	p	p	60	135	235	230
..	..	..	..	..	..	..	p	p	p	p	p	p	p
310	45	10	25	10	65	75	70	65	35	265	120	45	10
300	65	85	250	100	60	45	45	80	5	10	45	55	15
40	200	100	280	95	600	600	100	150	20	5	p	p	..
410	145	165	455	240	290	385	105	180	105	145	90	70	20
5	5	3	2	6	8	9	4	5	3	2	1	3	1

TABLE

	December 1927.				January 1928.			
Date	10	17	24	31	7	14	21	28
Temp. ° C.	21	22	21	22	21	20	22	22·5
pH	6·3	6·4	6·4	6·5	6·5	6·2	6·3	6·4
Peridinium sp.	p	p	p	p	p	p	p	p
Dictyosphaerium pulchellum, *D. ehrenbergianum*	p	p	p	p	p	p	p	200
Kirchneriella obesa var. *aperta*	p	..	..	..	..	..	..	..
Staurastrum paradoxum	800	400	200	100	p	p	p	p
Staurastrum schuurmani	200	200	100	200	100	p	p	p
Staurastrum subvestitum	200	200	100	p	p	p	p	p
Pediastrum duplex var. *clathratum*	200	100	200	100	100	p	p	p
Melosira ambigua	5600	6400	11600	12400	4800	2000	800	400
Microcystis flos-aquae	200	800	800	500	500	200	700	300
Dinobryon divergens	p	p	p	p	p	p	p	p
Mallomonas producta var. *marchica*	p	p	p	p	p	p	p	p
Difflugia oviformis	p	p	200	100	p	p	p	p
? *Actinosphaerium*	p	p	p	p	p	p	p	p
Synchaeta pectinata	p	10	20	10	p	p	p	p
Keratella cochlearis	200	100	50	100	100	20	10	p
Keratella quadrata valga	p	p	p	p	p	p	p	p
Brachionus angularis	p	p	p	p	p	p	p	p
Brachionus falcatus	395	1200	400	200	100	40	70	110
Tetramastix opoliensis	70	200	300	1000	2300	1500	400	300
Bosmina longirostris	45	20	50	30	10	80	10	40
Ceriodaphnia dubia	100	90	80	60	20	100	20	70
Daphnia longispina,	..	..	..	..	..	..	..	..
Mesocyclops macracanthus	70	30	120	110	30	480	50	140
Paradiaptomus colonialis	2	2	3	1	p	p	p	p

III.—*continued.*

February.				March.					April.				May.	
4	11	18	24	3	10	17	24	31	6	14	21	28	4	12
20	20	21·5	21	22·5	21	20	20	19	19·5	19	17	16	16	15
6·2	6·4	6·62	6·7	6·79	6·79	6·86	7	7	6·8	6·86	6·86	6·89	6·89	6·89
p	p	p	p	p	p	p	p	p	p	p	p	p	p	100
200	p	p	p	p	p	p	p	p	200	600	600	200	200	200
..	100	100	400	400	200	400	200	100	100	100	p	p	p	p
p	p	p	p	p	p	200	100	100	200	800	500	400	400	200
p	p	p	p	p	p	p	p	p	p	p	p	p	p	p
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
p	p	p	p	p	p	p	p	p	p	p	p	p	p	p
400	200	100	100	200	200	100	100	400	400	500	800	1030	990	3000
300	200	100	p	p	p	p	p	p	p	p	p	p	p	p
p	p	p	p	p	p	p	p	p	p	p	p	p	p	p
p	p	p	p	200	400	300	200	400	300	400	800	400	300	400
p	p	p	p	p	p	p	p	p	p	p	p	p	p	p
p	p	p	p	p	p	p	p	p	p	p	p	p	p	p
p	p	p	p	p	p	..	..	..	..	..	..	..	..	..
p	p	p	p	p	p	p	p	p	p	p	p	p	p	p
p	p	p	140	20	50	30	30	p	p	p	p	p	p	p
p	p	p	p	p	p	p	..	..	..	..	..	..	..	..
100	30	40	150	80	110	70	100	40	35	25	p	p	p	p
50	60	40	110	60	40	20	10	p	p	p	p	p	p	p
10	p	p	p	p	p	p	p	p	p	p	p	p	p	p
20	p	p	p	p	p	p	p	p	p	p	p	p	p	..
..	..	..	..	..	..	..	p	p	p	p	p	p	p	p
167	20	p	p	p	p	p	p	p	p	p	p	p	p	p
p	p	p	p	p	p	p	p	p	p	p	p	p	p	p

TABLE

	May 1928.		June.					
					old net	new net		
Date	20	24	2	9	16	16	23	30
Temp. °C.	15	14	11·5	11·5	11	..	11	7·5
pH	6·79	6·79	6·79	6·9	6·62	..	6·79	6·9
Peridinium sp.	500	100	200	200	200	330	580	730
Dictyosphaerium pulchellum, *D. ehrenbergianum*	..	..	..	..	..	..	..	..
Kirchneriella obesa var. *aperta*	p	p	..	..	..	..	..	..
Staurastrum paradoxum	100	100	100	100	100	..	..	..
Staurastrum schuurmani	p	..	..	..	..	..	..	..
Staurastrum subvestitum	..	..	..	..	..	..	..	..
Pediastrum duplex var. *clathratum.*	p	p	p	p	p	p	p	p
Melosira ambigua	2330	2220	2330	2900	11600	30950	25450	38650
Microcystis flos-aquae	p	p	p	p	p	p	p	p
Dinobryon divergens	300	300	1060	770	1310	17850	22600	57150
Mallomonas producta var. *marchica.*	100	300	200	100	100	p	p	p
Difflugia oviformis	p	p	p	p	p	p	p	p
? *Actinosphaerium*	p	p	p	p	p	p	p	p
Synchaeta pectinata	..	..	..	..	..	p	p	p
Keratella cochlearis	p	p	p	p	p	p	p	p
Keratella quadrata valga	p	p	p	p	p	220	110	120
Brachionus angularis	..	..	..	..	..	p	p	p
Brachionus falcatus	95	p	p	p	..	..	..	..
Tetramastix opoliensis	p	p	..	..	..	..	..	..
Bosmina longirostris	p	p	p	p	p	..	..	..
Ceriodaphnia dubia	..	..	..	..	..	..	..	..
Daphnia longispina	65	50	20	10	5	360	320	140
Mesocyclops macracanthus	p	p	p	p	p	50	110	70
Paradiaptomus colonialis	p	p	p	p	p	12	12	8

III.—*continued.*

July.				August.		Sept.		Oct.	Nov.	Dec.	Feb. 1929.	Apr.	May.	Jun.
											new net			
7	14	21	26	4	18	1	15	6	3	19	2	6	18	15
9·5	9	9·5	9	9	11	13	14	16	19	22	21	18·5	14	10
7	6·89	6·89	6·89	6·89	7	7	6·89	6·89	7	6·89	6·89	7	6·89	6·7
1760	1230	600	500	740	1440	2080	2760	2050	790	200	p	p	500	800
..	..	..	..	..	..	..	..	200	400	p	p	200	200	200
..	..	..	..	..	..	..	200	200	800	1200	100	200	100	100
..	..	..	400	500	300	100	100	200	100	600	100	500	800	200
..	..	..	..	..	..	..	..	..	200	200	400	300	400	200
..	..	..	..	..	..	..	100	200	200	200	100	..	..	..
p	p	p	p	p	100	200	100	200	200	100	100	100	p	p
27850	18700	9500	12750	16150	5950	20400	10000	37200	19850	1600	5650	7600	72900	65300
p	p	..	..	..	..	200	400	200	400	950	1750	1650	600	400
155750	140250	86150	60200	18800	6950	9400	6600	16550	p	p	1700	400	6900	8150
p	p	p	p	p	p	p	p	p	p	p	..	..	p	p
p	p	p	p	p	p	p	p	200	400	100	200	p	p	p
p	p	200	400	p	p	p	p	p	p	p	p	p	p	p
p	p	p	p	5	20	90	580	210	200	10	40	p	p	p
90	50	30	60	100	150	420	500	3780	800	50	10	20	410	450
220	260	170	120	270	560	510	870	200	10	40	80	140	140	80
p	p	p	p	p	p	p	p	460	50	70	..	..	..	p
..	..	..	..	..	..	..	..	p	p	1190	1280	540	300	p
..	..	..	..	..	..	..	..	..	p	p	400	p	..	..
..	..	..	..	..	p	p	p	p	p	p	p	p	p	80
..	..	..	..	..	..	..	..	..	..	..	p	p	40	124
200	100	50	50	135	400	190	80	120	280	10	5	60	..	..
50	30	30	15	50	20	35	90	130	660	15	210	180	75	70
2	3	1	p	p	p	p	p	p	p	p	17	10	12	4

EXPLANATION OF PLATE XIII.

FIG. 1.—Plankton sample from Florida Lake, 25/6/1927. ×40.
Peridinium sp.
Melosira ambigua.
Keratella cochlearis.
Keratella quadrata valga.
Bosmina longirostris.
(?) *Ceriodaphnia dubia.*
Mesocyclops macracanthus.

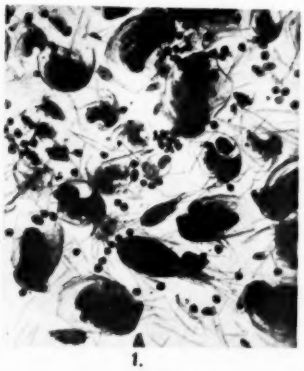
FIG. 2.—Plankton sample from Florida Lake, 13/8/1927. ×40.
Synchaeta pectinata.
Brachionus angularis.
Bosmina longirostris.
Ceriodaphnia dubia.
Mesocyclops macracanthus.

FIG. 3.—Plankton sample from Florida Lake, 8/10/1927. ×40.
Difflugia oviformis.
Melosira ambigua.
Brachionus angularis.
Brachionus calyciflorus dorcas.
Brachionus calyciflorus spinosus.
(?) *Daphnia longispina.*

FIG. 4.—Plankton sample from Florida Lake, 2/2/1929. ×40.
Brachionus falcatus.
Tetramastix opoliensis.
Trichocerca chattoni.

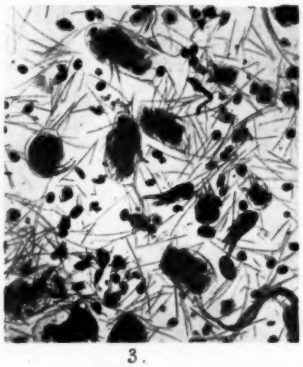
FIG. 5.—Plankton sample from Potchefstroom Dam, 1/10/1927. ×40.
Peridinium bipes.
Keratella cochlearis.
Keratella quadrata valga.
Bosmina longirostris cornuta.
Paradiaptomus colonialis.
Mesocyclops emini.

FIG. 6.—Plankton sample from Hartebeestpoort Dam, 29/4/1928. ×40.
Peridinium bipes.
Brachionus falcatus.
Keratella quadrata valga.
Filinia longiseta.
Pedalia mira.
Moina dubia.
Diaptomus syngenes.
Mesocyclops emini.

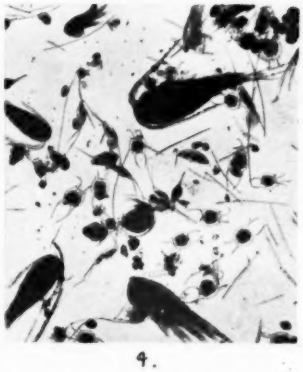


1.

2.

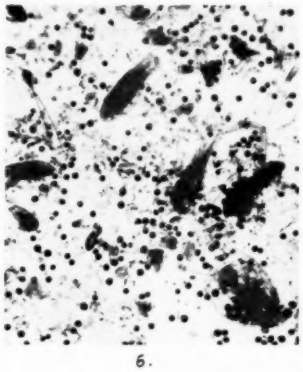


3.



4.

5.



6.

Neill & Co., Ltd.

THE PARASITISM OF *HARVEYA SPECIOSA* BERNH.

By Elaine M. Young.

(With Plate XIV), and seven Text-figures.

I. Introduction.

According to our present knowledge of the local vegetation, there are two species belonging to the genus *Harveya* which are thriving as angiospermous root parasites along the Witwatersrand. One of these, *Harveya randi* Hiern, occurs on the rocky exposed veld, and is characterised by the development in late summer of showy pink flowers on a short stocky flowering axis. Careful dissection of material by Mrs. Margaret Moss showed the connections between the long delicate lateral roots of this plant and those of *Anthospermum rigidum* E.Z., usually at some distance from both host and parasite, and at a depth of $1\frac{1}{2}$ inches in the soil. The other species, *Harveya speciosa* Bernh., has been found so far in only one area, which is moist, depressed, and marshy in character, and it is the parasitism of this plant which will be considered in detail in the succeeding pages.

Before proceeding with an anatomical study, it is proposed to discuss the nomenclature of this plant, since there is a certain ambiguity in the literature concerning its specific identity.

Several specimens are included in the Witwatersrand University collection, and all have been critically named by the late Dr. C. E. Moss in comparison with type specimens obtained at the Kew herbarium. Plants belonging to the species had been gathered in 1919 between Lady Grey and New England (Moss, 17765), at Port St. Johns in the same year (Moss, 4154), at Port Shepstone, Natal (Weeks, 65 *bis*), in the Katberg district, Eastern Cape Province, in 1926 (Moss, 14736), again in Natal towards the end of 1929 (Moss, 18165), and more recently by R. H. Flugge-de-Smidt in the Transvaal (Moss, 18420). All these specimens were found upon examination to fit the description of *Harveya speciosa* Bernh. in the Flora Capensis, except that the ovary in each case was glabrous. Careful examination of the type specimen of the species, however, revealed the fact that it also possessed a glabrous ovary, and not a " pilose-puberulous " one as Hiern had stated. The following note by Moss occurs on sheet

18165 in his herbarium: "The ovary in all the specimens I have seen (including the type specimen) is glabrous. Hiern's description of this organ in the Flora Capensis iv, ii, is erroneous. . . "; and further, on sheet 18420: "Several mature flowers were examined, all had a glabrous ovary as in the type specimen, but contrary to the description in the Flora Capensis."

In a recent publication, Smith (8) described specimens of the same plant collected by R. H. Flugge-de-Smidt at Geduld, Eastern Witwatersrand, as a new species, *Harveya anisodonta* Sm., using the glabrous ovary as the chief differentiating character between this plant and *Harveya speciosa* as described by Hiern.

Since the analysis by Moss showed Hiern's original description to be at fault, it follows that the plants described by Smith and also those already mentioned from the same and other localities included in the Moss herbarium belong to the type species (*sensu stricto*), and it is further evident that *Harveya anisodonta* Sm. is synonymous with *Harveya speciosa* Bernh.

II. Anatomical Study.

Towards the end of 1929 a number of fine specimens of *Harveya speciosa* Bernh. were brought in to the late Dr. Moss at the herbarium by R. H. Flugge-de-Smidt. The plants had been growing beside a number of apparent hosts, so that large sods holding the groups could be secured. All were found at Geduld, E. Witwatersrand. The sods were handed to the writer for sorting and selection of parasite with host attachments. Careful washing in running water over a period of several days loosened the soil sufficiently well to facilitate dissection. In a few instances the root attachments were easily obtained and conspicuously large. In such cases the host attacked was invariably *Berkheya radula* (Harv.) Burtt Davy, and the connections were close to the main rootstocks of both plants, which were in intimate contact (Plate XIV, fig. 8). The parasite root system formed an anastomosing rope-like mass, having a few roots in direct contact with those of the host, forming simple haustoria where they touched, but the majority developing masses of swollen tissue, having a storage as well as haustorial function, and pushing host and parasite roots apart. An interesting observation by R. W. Plant occurs in Hooker's Kew Journal, iv, 262, where he mentions a plant, which he imagines is an Orobanche, since its habits agree exactly with that parasite "usually found adhering to a thistle." The "thistle" referred to is undoubtedly *Berkheya radula*, the host most frequently attacked by this parasite.

In all the other affected species the attachment occurred between the more delicate lateral roots of both plants, some distance away from the

parent stocks. Of these, the most prevalent connections lay between Harveya roots and those of *Conyza podocephala* DC., but because of their small size and distance away in the soil, it was often not possible to secure unbroken specimens.

Haplocarpha scaposa Harv. was usually surrounded by flowering branches of the parasite, but the actual attachment was slight and often considerably remote from the two main axes. A grass was found attached to a Harveya root system, which was already in contact with Conyza, but since it was not in flower it could not be determined with certainty. The sods included a woody rootstock belonging to a leguminous herb, also not in flower. Its heavy axis extended between two erect floral branches belonging to the parasite, but here again the actual connection lay between the smaller lateral roots of both plants. Several isolated parasitised roots were left in the debris, probably broken away when the sods were cut, or during the washing-out process. After a study of the anatomical features of the various hosts, these fragments could be correctly identified as belonging to the plants mentioned above, since the tissues of each were sufficiently distinct to make their classification comparatively simple. The effect on the host plant varies with the species parasitised : *Berkheya radula* not only had no flowers on any of its shoots, but its vegetative development was perceptibly reduced, while the other hosts, particularly *Haplocarpha scaposa*, suffered only to a slight extent.

(A) *Anatomy of Host Plants.*

(*a*) *Berkheya radula* Burtt Davy.—This plant thrives in a heavy marshy soil in low-lying areas. It possesses a short robust rhizome, a rosette of spiny-margined leaves, and at intervals erect spiny flowering branches bearing deep yellow composite flowers. A number of large straight roots, developed from the rhizome, assume buttress-like positions in the soil. Although they are totally embedded in the soil, the aeration and other environmental conditions are unusual. Structurally they resemble the pneumatophores of mangroves and the buttress roots of rain forest trees, as described by Warming and others (12, 4). From these straight roots smaller branch roots arise, having a typical root structure.

The stele of the straight root is unusually wide, has a well-developed pith, and conspicuous medullary rays, at the commencement of which the seven protoxylem groups can be distinguished. The secondary xylem includes large vessels and wood fibres, and is separated from the collateral secondary patches of phloem by some cambium. Both the wide persistent cortex and the pith include some stone cells, with large connecting pits. (Plate XIV, fig. 9.)

The smaller roots possess the usual centralised solidity. The centre of the stele is occupied by five protoxylem groups, which can be made out with difficulty, and a mass of secondary xylem somewhat eccentrically formed. The cambium and small patches of phloem are crushed within the narrow persistent cortex which has a wide exodermis, similar to that of many swollen monocotyledonous roots, and some remains of root hairs in the limiting layer.

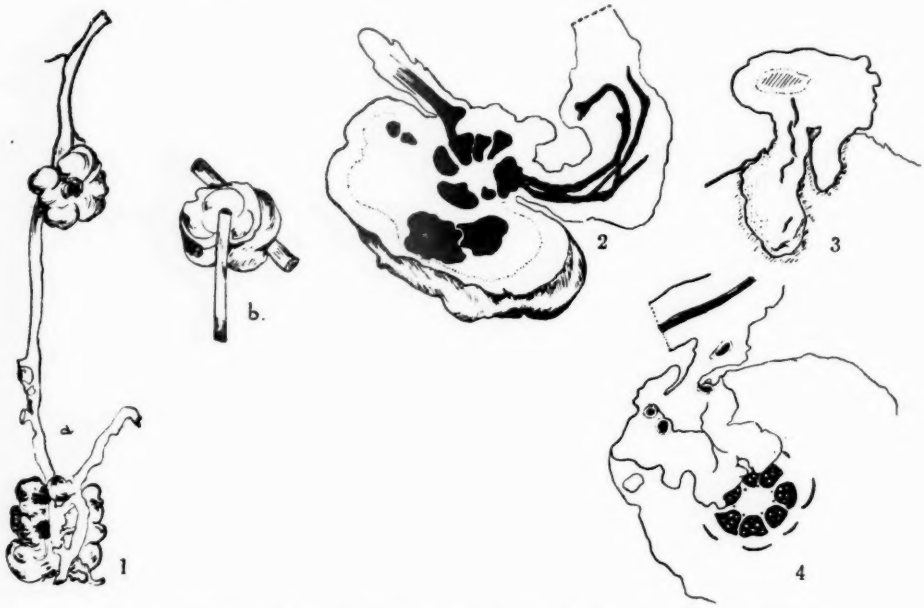


FIG. 1.—*Berkheya radula:* small roots surrounded by tubers developed from parasite—at (*a*) parasite and host run vertically; at (*b*) host is vertical and parasite oblique. × 4.

FIG. 2.—Partially macerated tuber with two young floral branches, showing tracheidal skeleton. × 5.

FIGS. 3 and 4.—Outline drawings of haustoria penetrating Berkheya straight roots.

(*b*) *Conyza podocephala* DC.—The roots of this plant, in accordance with a number of the Compositae, have conspicuously wide medullary rays, which are parenchymatous and appear in an irregular abrupt manner in the stele. No ray bundles were found. The xylem includes a considerable development of secondary wood vessels with wide lumina, fibres, and three clearly marked protoxylem groups in the centre. The cambium and phloem offer no peculiarities, but the phloem patches are flanked by bundles

of sclerenchyma. The unthickened endodermis is surrounded by narrow, sloughing off cortical cells, replaced, in the older roots, by layers of cork (fig. 14).

(B) *The Parasite and its Haustoria.*

Harveya speciosa Bernh. produces no clearly marked rootstock, since the aerial flowering shoots most frequently develop from tubers which are surrounded by an intricate anastomosing mass of roots (Plate XIV, fig. 8). The branches may reach 1 inch in diameter, but there is a complete absence in all the organs of any mechanical strengthening tissue. The stele in the aerial shoots and roots is marked by the presence of scalariform tracheids, interspersed with considerable quantities of parenchyma. In the root the seven phloem groups alternate normally with an equal number of protoxylem elements. The epidermal layer in both branches and roots consists of slightly brown but otherwise unmodified cells. As is characteristic of other Scrophulariaceous root parasites there are no root hairs developed.

The haustoria may be produced simply in direct relation to the host root, or, as has been mentioned earlier, they may be storage organs, in which case they swell out into tuberous structures. Whether there is any later enlargement or not, the haustoria are exogenous in origin, being extensions of the root cortex, and having at their apices cells rich in protoplasm, with conspicuous nuclei.

In the simple haustoria a central set of tracheids may arise and connect with the root stele (fig. 3), or there may be two or more main tracheidal branches (Plate XIV, fig. 9). After contact has been established, the epidermal and remaining cortical cells of the host are disorganised in that area, while the haustorium grows in length and expands in a lateral direction to form an approximately isodiametric structure. In contrast to the narrow, well-defined absorbing organs developed from such parasites as the Dodder (5, 6), these haustoria are somewhat diffuse. The actual extent of each haustorium, however, is readily distinguished by the difference in size, shape, and orientation of the cells belonging to parasite, particularly when sections pass through the long axis of the host. The apex of the haustorium is presumably rich in cell-destroying enzymes, since its boundary is marked by necrotic host cells. When the phloem, medullary rays, and, to a slight degree, the xylem tissue have been destroyed, the tracheidal system in the haustorium connects with the host xylem directly, or there may be a border of parasite cells rich in protoplasm between the two sets of tracheids (Plate XIV, fig. 9). One or more haustoria may develop at any point of contact between host and parasite (fig. 3), and more than one parasite root may attack a single host root. In a number of instances two distinct sets of

haustoria have penetrated the host root at different times, but in all such cases the whole haustorial mass belonging to one set dies off, leaving a hollowed out cavity containing a few isolated dead cells (Plate XIV, fig. 9). Individual cell haustoria are described in a number of parasites, such as those developed from Cuscuta stems described by Pierce (5, 6), and in Worsdell's account of the Bamboo root parasite Christisonia (13), but such structures could not be found in Harveya roots, possibly on account of the age of the material.

Such a simple type of haustorial activity described above has only been found in connection with the large straight roots of Berkheya. Far more commonly there occur, as has been mentioned, masses of hypertrophied haustorial and storage tissue, similar in all respects to the tubers of *Christisonia subacaulis* Garden.

As may be seen from figs. 1, 8, these tubers vary considerably in size, the largest being 1½ inches in diameter, and may partially surround the stilt roots of Berkheya or completely envelop the small roots of both Berkheya and Conyza. The production of a tuber occurs, irrespective of the direction in which the host and parasite roots are growing, provided they are in contact at one point. The host and parasite may run approximately parallel as in fig. 1 (*a*) where the longer root belongs to the host, or the parasite may lie at a considerable angle to the host root (fig. 1 (*b*)). The internal differentiation of the tuber is symmetrical about the host root, so that in cutting any series of sections the position of the latter is of primary importance in relation to the razor edge. Secondly, when the host xylem is seen in transverse view in any of the sections, it is possible to relate it to the tracheidal system of the tuber, whereas the maze of ramifying xylem elements in any series of oblique sections prevents any adequate interpretation of host and parasite connections.

The tuber begins development as a proliferation around the region of contact between both roots, till it becomes a kidney-shaped storage organ. The carbohydrate reserve is in the form of starch, which is carried to the periphery and deposited in a wide zone of parenchymatous cells (fig. 5). As growth proceeds, the tuber becomes more irregular in outline, but internally there are two main lobes consisting of the wide peripheral starch layer surrounding masses of cells rich in proteins which correspond to the "proteid bundles" described by Worsdell for Christisonia. The margins of these bundles form a series of convolutions following to some extent the lobing of the whole tuber. Each bundle consists of three distinct zones of cells: (*a*) an innermost zone of scalariform tracheids with a varying amount of interspersed parenchyma; (*b*) a surrounding layer of cells rich in protoplasm showing definite cambial activity; (*c*) an outermost zone of more mature thin-walled cells with large central vacuoles. The nuclei

in the cells comprising the two outer zones are conspicuously large. Finally, this outermost layer of the proteid bundle merges into the peripheral starch-storing parenchyma (figs. 5, 6).

The whole of the surface in contact with the host root is haustorial in character for it destroys the enveloped peripheral host tissues, and, as may be seen in fig. 4, the phloem, medullary rays, and a portion of the xylem of the part affected. Tracheids differentiated in the haustorium link up the host and parasite xylem in the usual way. As the tuber enlarges, a mass of tracheids appears somewhere along the haustorial strand, usually nearer to the parasite stele itself (fig. 7, *e*). These tracheids have their

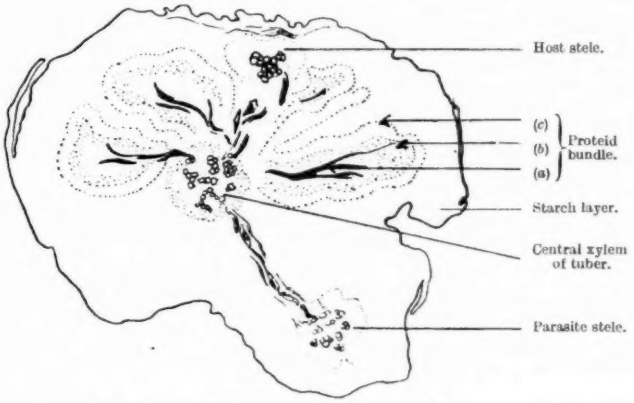


FIG. 5.—Diagram of tuber seen in transverse section, showing tracheidal system and the three zones of each proteid bundle. × 14.

long axes at right angles to those linking host and parasite. At the same time additional tracheids appear in the various proteid bundles forming the innermost zones of these masses. They are connected directly with the host xylem (fig. 7, *f*, *g*). Further, a series of tracheids is differentiated in the outer starch layer and joined to the central xylem mass of the tuber (fig. 7, *b*, *c*). This intricate system connecting the host-conducting elements with those of the parasite forms an efficient means of transporting food to the proteid bundles on the one hand and the starch layer on the other.

Besides the indications of food passing into the proteid bundles of the tuber, there is evidently a translocation *via* the haustorial xylem to the parasite root itself, where some starch not transported to other parts is deposited in the cortex, and any further excess is then diverted back to accumulate in the tuber, which later will give rise to one or more aerial shoots and additional branch roots. The small apparently isolated

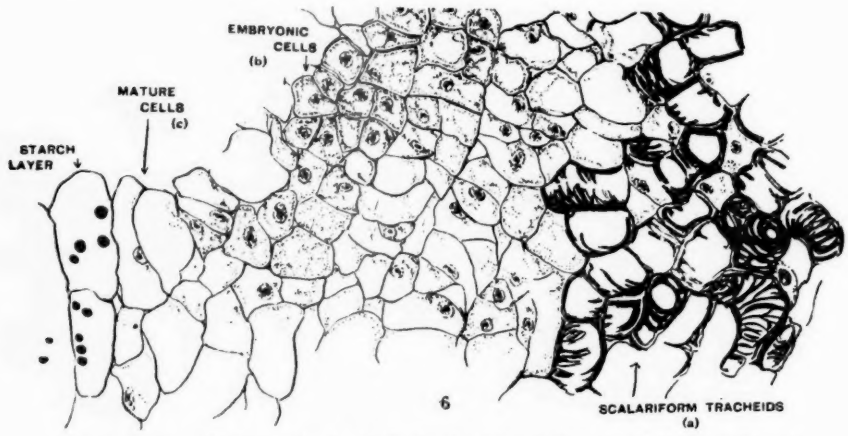


FIG. 6.—Portion of tuber section in detail, showing (*a*) scalariform tracheids, (*b*) embryonic and (*c*) mature cells, transparent starch cells. × 120.

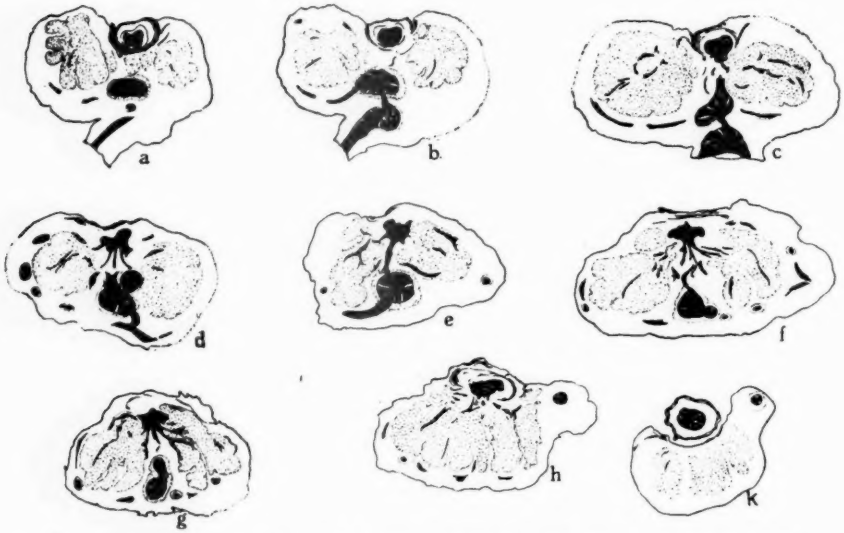


FIG. 7.—Series of outline drawings of hand-sections through tuber enveloping Berkheya small root (seen in fig. 1, *a*). In (*a*), (*b*), (*c*) the oblique parasite is visible, connecting by tracheids with central tuber xylem. The connecting tracheidal system between host (black-pitted area) and tuber show in remainder of series—the proteid bundles are the dotted area. × 8.

tracheids found in any one section can be linked up by means of neighbouring sections when the series has been cut by hand. The thinner more complete microtome series have been used only for the detailed study of cell structure, not for tracing the branch xylem elements, since these are inclined at a considerable angle so that thin sections would separate them into indistinguishable small dissociated groups.

In all the material examined the continuity of the host stele was never materially affected by the encroaching haustorial surface, so that the conduction of solutes to the aerial host parts proceeds along a continuous passage.

Employing the aqueous aniline blue stain test upon various parasite sections in order to ascertain the amount of phloem developed, it has been found that although the parasite roots develop phloem alternately with the xylem strands, there are no traces of phloem in either the simple haustoria or the tubers. The efficient production of xylem extending to the limits of the latter and connecting parasite with host warrant the suggestion that the tracheids are responsible for the transportation of prepared foods from the various host tissues to the parasite.

The development of a tuber may cause some divergence in direction of growth of the host root, which continues developing below the tuber at a considerable angle to the portion above the parasitised area. But a number of almost perfectly parallel host and parasite roots in contact with one another were found in the affected Conyza roots. One section of a series of preparations is reproduced in Plate XIV, fig. 10, and illustrates such a type. Sections passing through the upper portions of the connected organs show the embryonic cells belonging to the outer zones of the proteid bundles ; those passing through the centre of the tuber expose the tracheids connecting the host and parasite. In comparison with the tubers enveloping Berkheya roots, these showed less consolidation of the tracheidal mass in the centre, while the presence of interspersed parenchyma between the tracheids gives a closer resemblance to the arrangement in the parasite stele itself, and, further, the dissolution of the host xylem is comparatively slight.

In parasitised material of both host plants there were frequent instances of lateral roots having been arrested in development by encroaching tubers. In Conyza one lateral root had evidently been thus killed off by the tuber, leaving as residue brown separated cells, including a few xylem elements. The Berkheya lateral roots appeared to have developed to a much greater degree before being pressed upon by the edge of a tuber. The root, originating outside the protoxylem of a straight root, had passed beyond the epidermis, but had become a distorted mass as a result of the outside pressure. The strongly developed vascular tissue absorbs excessive

quantities of stain and bears a superficial resemblance to the sharply defined haustoria of certain stem parasites.

Interesting cases of haustorial development are described by Barber and also by Benson in a discussion of the parasitism of certain members of the Santalaceae (1, 3). The plants examined, *i.e. Santalum album*, *Exocarpus* spp. and *Thesium* spp., are hemiparasites, as are the majority of species in the family. In the latter the haustorium is wide and possesses a large amount of lignified tissue connecting with a strikingly well-developed host stele. The haustorium expands to form a bulbous structure resembling to a considerable extent the tubers formed by Harveya and Christisonia, and appears to be intermediate between these types and the simple direct haustoria developed by *Striga lutea* Lour., and other root parasites (10, 11). The formation of tubers has thus brought about a combination of haustorial activity and food storage prior to floral development in a single organ.

Summary.

1. Two species of Harveya have been recorded for the Witwatersrand, and the parasitism of one of these is discussed in detail.

2. The roots of the parasite form an anastomosing mass, certain branch roots attacking the host directly, and others by the development of a lobed connecting tuber, which is primarily a storage organ, later producing aerial floral branches as well as lateral roots.

3. Each tuber possesses a central xylem mass, also branch tracheids passing from the host stele to various parts of the lobes, probably conducting prepared foods of which the carbohydrates are stored as starch in the peripheral cells, and proteins in cambiform cells comprising "proteid bundles."

4. The simple haustoria penetrating some of the straight roots of *Berkheya radula* are isodiametric, diffuse at their apices, reaching as far as the host xylem, part of which may be dissolved. In the majority of the Berkheya and Conyza roots, however, the haustoria expand to form conspicuous tubers.

5. Phloem development is normal in the parasite roots, but no trace of sieve tubes or companion cells can be found in either the simple haustoria or the tubers. The parasite xylem consists chiefly of scalariform tracheids interspersed with considerable quantities of parenchyma.

6. In connection with both Harveya and Conyza roots the tuber may not only function as a haustorial organ over that part of its surface which is in direct contact with a host root, but, by its development and pressure against the host, may cause the stunting or complete suppression of lateral roots developing from the host.

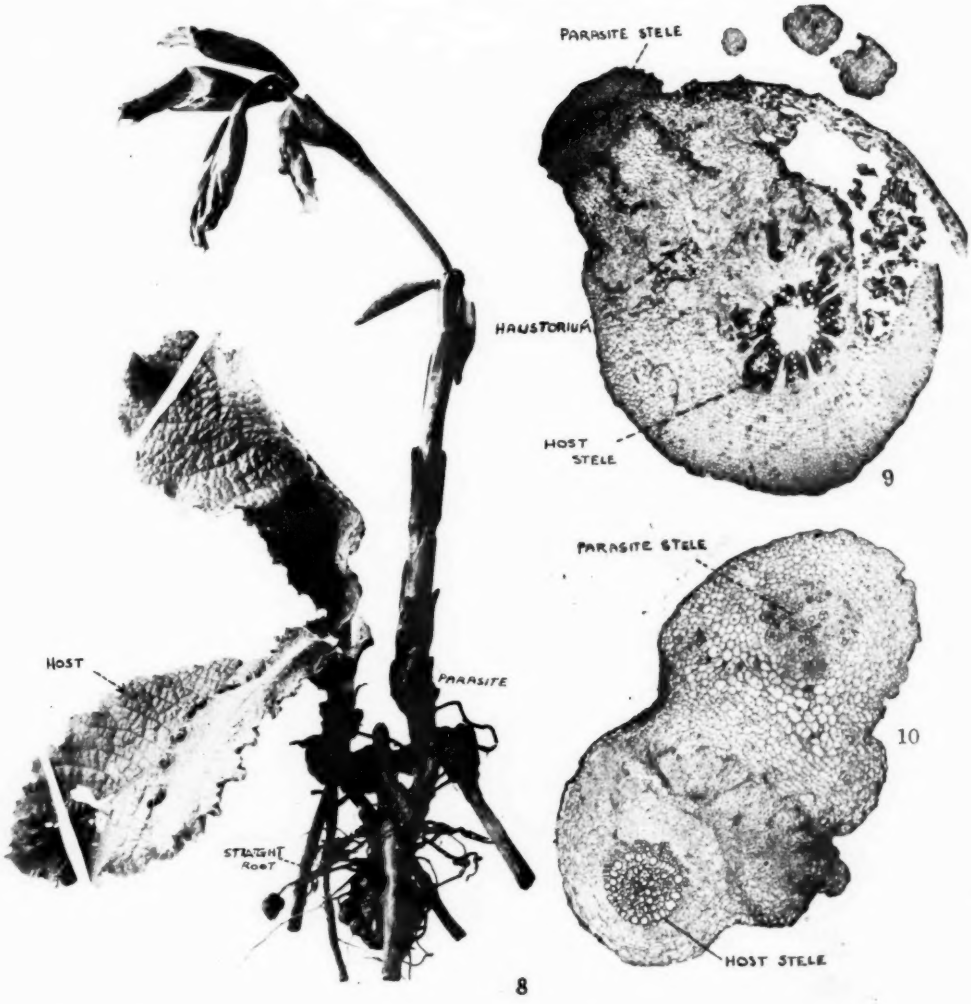


FIG. 8.—Flowering plant of *Harveya speciosa* attached to *Berkheya radula*, showing tubers exposed. ($\frac{1}{2}$ natural size.)
FIG. 9.—T.S. parasite and Berkheya straight root, showing haustorium and tracheid formation. ×14.
FIG. 10.—T.S. connected Conyza and Harveya roots, showing tuber with its proteid bundles. The linking-up tracheids are not visible at this point. ×38.

Neill & Co., Ltd.

7. The tubers in *Harveya speciosa* Bernh. resemble those of *Christisonia sp.* in acting as storage as well as haustorial organs, which, later, give rise to floral branches and additional roots. In their adaptation to their dual function, however, they have developed a more complicated internal structure than any haustorium previously described.

Grateful thanks are due to Mrs. Moss for granting permission to make a record of the taxonomic notes made by the late Professor Moss; to Messrs. W. Paff for the photographic work and R. H. Flugge-de-Smidt for the supply of material; to Miss E. L. Stephens for her helpful suggestions during the preparation of the manuscript.

Department of Botany,
University of the Witwatersrand,
Johannesburg.

BIBLIOGRAPHY.

1. Barber, C. A., "The Structure of the Mature Haustorium of *Santalum album*," Mem. Dept. Ag. Ind. Bot. Ser., vol. i, No. 1, Part II.
2. Beck, G., "Die Orobanchaceae," Natur. Pflanz., iv, Teil Abt. 3b, pp. 123–132.
3. Benson, M., "Root Parasitism in Exocarpus," Ann. Bot., xxiv, pp. 667–677, 1910.
4. Francis, W. D., "The Buttresses of Rain Forest Trees," Kew Bull. Misc. Inf., i, pp. 24–26, 1931.
5. Pierce, G. J., "On the Structure of the Haustoria of some Phanerogamic Parasites," Ann. Bot., vii, pp. 291–327, 1893.
6. Pierce, G. J., "A Contribution to the Physiology of the Genus Cuscuta," Ann. Bot., viii, pp. 53–119, 1894.
7. Reed, T., "On the Anatomy of some Tubers," Ann. Bot., xxiv, pp. 537–549, 1910.
8. Smith, C. A., "A New Harveya from the Transvaal Highveld," Kew Bull. Misc. Inf., ii, pp. 65–67, 1931.
9. Solereider, H., Anatomy of the Dicotyledons, vols. i, ii. Transl. by Boodle and Fritsch; revised by Scott, 1908.
10. Stephens, E. L., "The Structure and Development of the Haustorium of *Striga lutea* Lour.," Ann. Bot., xxvi, pp. 1067–1076, 1912.
11. Stephens, E. L., "Note on the Anatomy of *Striga lutea* Lour.," Ann. Bot., xxvi, pp. 1125–1126, 1912.
12. Warming, E., "Tropische Fragmente II.," Eng. Botan. Jahrb., B, iv, pp. 519–548, 1883.
13. Worsdell, W. C., "On the Comparative Anatomy of certain Species of the Genus Christisonia," Ann. Bot., ix, pp. 103–106, 1895.